REDEFINING HAWAII URBAN HOUSING AFFORDABILITY THROUGH ADAPTIVE REUSE, PREFABRICATION, LIFECYCLE BUILDING AND FLEXIBLE DESIGN

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School of Architecture
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We certify that we have read this Doctorate Project and that, in our opinion, it is satisfactory in scope and quality in fulfillment for the degree of Doctor of Architecture in the School of Architecture, University of Hawai'i at Mānoa.

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ABSTRACT

Providing housing that is affordable in Hawaii is a complex and compounded problem. However, most of the discussion around housing affordability solutions for Hawaii focuses around changes in government regulations, subsidies, and land cost; not necessarily around the actual building design.

This project proposes a method of providing quality, long-term housing in Hawaii that is affordable, sustainable and desirable to inhabit by taking advantages of the construction cost benefits achieved through adaptive reuse, prefabrication, lifecycle building, and flexible design. The goal of this project is to encourage more sustainable urban housing in such a way that extends a the usable life of Hawaii’s existing building stock and redefines Hawaii’s approach toward providing housing that is affordable.

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PROJECT STATEMENT

Housing affordability has plagued Hawaii for decades. The problem not only affects families with low incomes but also those who earn moderate incomes who are unable to afford the homes they desire and also do not qualify for government assistance for housing. The traditional way that government assistance for housing is set up (both federally and locally) enables only the very rich or the very poor to afford urban housing here. Some may argue that Hawaii's housing situation works toward maintaining Hawaii's relatively high quality of life by limiting the attractiveness of Hawaii and therefore limiting the amount of in-migration to the state (which could wreak havoc on Hawaii's environment).[1] But the issue of housing affordability in Hawaii creates a huge income and social gap while also reducing the quality of the workforce in the islands which can also affect Hawaii's quality of life as well. Many educated, young professionals who might otherwise be able to afford their own place on the mainland are either stuck at home living with their parents, forced to cohabitate with roommates in cramped, deteriorating apartments, sit in hours of traffic to get to work, or are ultimately lured away to the mainland U.S. where greater opportunities are available with less compromise.

There are a number of factors that have shaped Hawaii's current housing predicament including Hawaii's finite sources of developable land, a reliance on imported goods (including construction materials), lengthy development processes, general anti-development stances by the public, and restrictive government housing policies. Rarely is the architecture or design of housing mentioned as a solution for housing affordability for Honolulu. As a result, the housing products that are developed are different versions of the same thing – a fixed-in-time 'solution' that perpetuates Honolulu's housing situation.

Furthermore, as an island economy, Hawaii is limited to the amount of local raw materials resources available for construction and is highly dependent on imported goods, including most materials and components used in building construction. As a result, building materials (and goods in general) continue to be higher here than in the Mainland U.S. Despite innovations in alternative and sustainable energy resources, fuel costs continue to rise, making the transportation of goods a somewhat significant factor in the cost of construction for Hawaii.

The original goal of this project was to encourage significant development of a reuse and recycled materials industry for Hawaii in order to make housing more affordable in Hawaii, through the design of urban multi-family housing system that is designed for re-use, providing a means of making quality housing more affordable. Recycling and reusing materials from demolition sites for new construction or even recycling the building itself (rehabilitation, renovation, adaptive reuse, etc.) are a few methods of reducing initial construction costs for affordable housing projects by using material available locally. Unfortunately, Hawaii's locally available recycling market is severely limited, requiring builders to order most of its recycled

[1] Leroy O. Laney, "Cost of Living: Why is the cost of living in Hawaii so high? Will it ever come down?" *The Price of Paradise.* Edited by Randall W. Roth, (Honolulu: Mutual Publishing, 1992), 31.

material from the mainland or abroad. Although Hawaii could benefit tremendously from a construction and demolition recycling and reuse, there has been little activity and incentives for development in this industry. The result is that the affordability of housing in Hawaii will not reap the benefits of a recycling/reuse industry for quite some time.

This project aims to propose a different model for urban housing design for Honolulu from the approach of controlling construction costs in a way that utilizes and prolongs the useful life of existing building resources in Hawaii while meeting the needs and desires of its residents, the demands of Hawaii's housing market, and is ultimately affordable to local residents.

The first section of this document provides a generalized background on the various influences on the affordability of housing in Hawaii as well as a discussion on various concerns addressing "low-income housing" and the cost effects design has on housing. The second section of the project analyzes past experimentation in housing design and production, particularly during the 20th Century and illustrates the overlapping of several driving ideas behind three movements – prefabrication, flexible housing design, and lifecycle building. The end result is the proposition and testing of a hybrid solution using adaptive reuse, prefabrication, flexible housing design, and lifecycle building. The goal for this project is to design a building that not only addresses immediate costs associated with housing construction, but the long-term costs as well.

The design portion of this project involves the adaptive reuse of an existing building in Hawaii by converting it into flexible, yet standardized, dwelling units that may be combined, reconfigured, or disassembled to exemplify the design guidelines put forth by this research document. The final section of this document outlines cost parameters for the design project that affect the financial feasibility of the designed project.

RESEARCH METHODS

Literature research is the primary research method used throughout this project on all topics. A combination of personal interviews and literature research was conducted to understand the various costs associated with housing, the reasons why housing in Hawaii is continuously unaffordable, and how to design for affordable housing.

From this research, a myriad of causes emerged with land cost and availability rising as the biggest culprit of influencing housing affordability. The solutions suggested in the research literature had more to do with government intervention and creative conversions of land use on the side of the developer which does not allow for much of an architectural solution. Because of this, the focus of the research shifted to the construction costs associated with housing and what could be done to lower these costs.

The original hypothesis of this project was to determine the feasibility of using a panelized building product that was made out of recycled and recyclable materials (with the assumption that the production could be made locally). Unfortunately, through more literature research and personal interviews, it was determined that a recycled building material industry for Hawaii was more or less a non-starter and that material reuse was a perhaps a better option. The hypothesis then shifted focus to determine the feasibility for designing housing in Honolulu in a way that they can be deconstructed and its material reused to support the small but promising reuse material industry as a way to reduce material costs.

This shift in hypothesis required more literature research into how to design for deconstruction. During this research, design principles were discovered that overlapped with principles of flexible housing which had historical ties back to prefabrication (or rather methods of housing mass-production). More historic-interpretive analysis was done on both flexible housing and prefabrication to understand the underlying goals, strengths, weaknesses, and design elements of each movement or mode of thinking. A comparison/contrast exercise was then conducted to understand the relationships between each movement and to suggest guidelines for a hybrid approach toward improving the quality of urban housing that is affordable for Honolulu residents.

To test the guidelines and the hypothesis of this project, a hypothetical adaptive reuse project was then developed based on the overlapping best or recommended practices and goals of each housing movement. An existing building was selected through the best practices principles found in the comparison/contrast exercise.

At the end of the conceptual design process for the building a number of issues arose that would ultimately affect the ‘affordable’ component of this project. A list and description of these cost parameters was compiled to identify key cost considerations that affect the financial feasibility of the adaptive reuse design proposed by this project.

1.0 THE PROBLEM: HOUSING AFFORDABILITY IN HAWAII

Living in Hawaii, goods cost more and housing is no exception to the rule. The issue of the cost of housing in Hawaii, particularly on Oahu, seems to be a forever ongoing discussion with much of the cause being pointed to state and local government. However, housing affordability is a relative term that is ultimately measured against a household's income where Hawaii residents suffer from a disproportionate earnings-to-living cost comparison especially when it comes to housing.

Although the State's median household income is about 27% higher than the national median household income, its median value of owner-occupied housing units is 181% higher than the national median resulting in a lower homeownership rate throughout the state as illustrated by Table 1**.**

Table 1. Homeownership & Income Data for Honolulu, Hawaii[2]

	HONOLULU COUNTY	HAWAII STATE	USA
Homeownership Rate, 2005-2009	56%	58.1%	66.9%
Median Value of owner-occupied housing units, 2005-2009	$537,800	$521,500	$185,400
Median Household Income, 2009	$67,019	$63,741	$50,221

Because income levels in Hawaii are high, many residents do not qualify for government assistance aimed at making housing affordable through supplementing income nor will they meet the requirements for government-assisted housing projects.

In Randall W. Roth's *The Price of Paradise*, University of Hawaii Professor of Economics, Sumner J. La Croix listed five primary reasons why Honolulu housing prices are higher than those in the Mainland U.S.: (1) restricted amounts of developable land, (2) housing prices tend to be higher in cities with a better quality of life, (3) continuous increasing in tourism industry results in residents willing to pay more for housing because they anticipate higher salaries, (4) Japanese investment in the 1980s pushed up housing prices, and (5) construction costs in Hawaii tend to be higher than those on the mainland.[3] These reasons were just a snapshot of housing affordability in 1992 but 20 years later, several of these reasons still remain relevant.

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[2] "Honolulu County, Hawaii." *2010 U.S. Census Bureau State and County QuickFacts*. http://quickfacts.census.gov/qfd/states/15/15003.html (Accessed 09 January 2012).

[3] Sumner J. La Croix, "Cost of Housing: Can government make housing affordable?" *The Price of Paradise: Lucky We Live Hawaii?* Edited by Randall W. Roth, (Honolulu: Mutual Publishing, 1992), 136-137.

Unfortunately, the solutions proposed by La Croix and other proponents for affordable housing has been mostly political or economic in nature. They almost always propose some form of government intervention whether it is implementing an affordable housing requirement, reducing demands on developers, creating tax credits for low-income housing developments, etc. Few proposed solutions for Hawaii approach reducing the cost of housing from the construction point of view. While housing design in itself is an ongoing exercise in reducing construction cost without sacrificing quality, this project attempts to take it one step further to creating a housing product that is continuously useful, addressing concerns of limited local resources, transportation costs, and labor.

1.1 Defining Affordability

"Affordable housing" is a term commonly used to describe housing that is sold or rented below market value for an area's median income. In formal discussion regarding housing however, many authors generally use the definition of "affordability" determined by the U.S. Department of Housing and Urban Development (HUD) which indicates that a household to pay no more than thirty percent of its annual income on housing. Any household or family that pays more than that for housing is considered to be 'cost-burdened' which means that they will have difficulties paying for other necessities such as food, transportation, and healthcare.[4]

For the fiscal year of 2012, the U.S. Department of Housing and Urban Development (HUD) has calculated Hawaii's overall area median income at $79,400 with metropolitan areas having an AMI of $82,700 and its non-metropolitan areas having an AMI average of $73,400.[5]

The following table illustrates the limits of affordable housing annual costs if we apply HUD's definition of affordability to the State of Hawaii's area median income as well as its metropolitan and non-metropolitan areas for the values given above.

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[4] United States Department of Housing and Urban Development. *FY 2009 Income Limits Briefing Material.* http://www.huduser.org/portal/datasets/il/il09/IncomeLimitsBriefingMaterial_FY2009. (Accessed 30 September 2010).

[5] U.S. Department of Housing and Urban Development Office of Policy Development & Research. "FY 2012 Median Family Incomes for States, Metropolitan and Nonmetropolitan Portions of States." *FY 2012 Income Limits Briefing Material.* 1 December 2011. http://www.huduser.org/portal/datasets/il/il12/IncomeLimitsBriefingMaterial_FY12_v2.pdf (accessed February 15, 2012), 31.

Table 2. Affordability Index for Hawaii's Area Median Income (FY 2012)[6]

AREA	AREA MEDIAN INCOME (AMI)	HOUSING COSTS (30% OF AMI)	HOUSING COST/MONTH
Metropolitan	$82,700	$24,810	$2,068
Non-metropolitan	$73,400	$22,020	$1,835
State Average	$79,400	$23,820	$1,985

It is important to note, however, that the values given above merely a reference point for determining affordability in Hawaii. These numbers show affordability for only those people who at least earn the overall average median incomes for Hawaii. This value of affordability is in no way affordable to those who earn less than this amount. For these households and families, spending almost $2,000 or more per month on rent or mortgage payments would not be affordable.

Income Limits & Housing Types

Governments at all levels recognize the need for affordable housing throughout the U.S. and delegate funds to assist affordable housing developers and/or families in need of affordable housing. HUD has established income limit restrictions that are generally accepted definitions by public and private housing projects as well as individual households that are recipients of federal subsidy programs. These limits are aimed to prioritize projects and households receiving government assistance, as well as help ensure that those who need affordable housing the most will receive it.

The problem with Honolulu, however, is that the housing provided here are only affordable to the two extreme ends of the income spectrum. Many complain that housing here is only affordable to the very rich while government assistance makes housing affordable to the very poor.

The City and County of Honolulu's Mayor's Affordable Housing Advisory Group categorizes the housing market on Oahu into three categories: assisted housing, affordable/workforce housing, and market rate housing.[7] The following sections outline the definitions of HUD-established income limits and the types of housing in Honolulu that each income group qualifies for.

Very Low-Income and Low-Income

"Very low-income" households are those households whose earnings are less than 50% of their area's median income. These households are eligible for Federal and State assisted public housing projects as well as Section 8 vouchers. "Low-income" households are defined as households whose earnings are between 50-80% of the median income for the area in which

[6] U.S. Department of Housing and Urban Development. "FY 2009 Income Limits Briefing Material." http://www.huduser.org/portal/datasets/il/il09/IncomeLimitsBriefingMaterial_FY2009.pdf (Accessed 16 September 2010).

[7] Mayor's Affordable Housing Group. *Comprehensive Housing Strategy for the City and County of Honolulu*. Final Report. (Honolulu, 2008), 4.

they live.[8] While the federal government distinguishes between low-income and very low-income households, the City and County of Honolulu lumps all households earning less than 80% of Hawaii's area median income as low or lower income households. These households are eligible for Federal and State assisted public housing projects as well as Section 8 vouchers.

Assisted Housing

Assisted housing is housing that is intended for very low- to low-income households and must therefore receive some sort of government assistance in order to be economically viable. Conventional financing bases its loan amounts on a borrower's income and their ability to pay back the loan. Because the nature of low-income housing projects essentially collects discounted rents, their means of income limit the amount of money developers are able to borrow using conventional financing. Therefore, low-income housing requires a significant amount of assistance by investor tax credits, grants, subsidized loans, etc. to make up the difference between its rental income and the amount of money needed to build and maintain the project.[9]

Usually, assisted housing projects are required by their subsidiaries to impose household income limit restrictions to ensure that families who need the assisted housing will get it. These restrictions are enforced in order for a project to comply with requirements imposed by federal or state governments in order to receive funding, subsidies or other forms of assistance that make low-income and public housing developments economically viable. Households that are eligible for assisted housing often are eligible for income-based government assistance such as housing vouchers.

One of the problems in Hawaii is that it takes an income of 205% of the AMI to qualify for the current median priced home of $600,000.[10] Because there is such a huge gap between Hawaii's household income and its median housing prices, Hawaii would benefit more from assistance that increases the supply of affordable housing rather than assisting with resident income.

There are a variety of assisted housing types in both built and managed by public and private entities. Public housing is government-provided and managed housing exclusive to households who qualify under HUD income limits. There are also low-income housing projects that are developed and managed by private developers. These projects are generally funded and/or made feasible by the Low-Income Housing Tax Credit (LIHTC) program, federal block grants received by the State government, and other federal programs.[11] The State of Hawaii prefers to use the federal funding it receives toward low-income rental housing because it is easier to

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[8] Alan Mallach. *A Decent Home: Planning, Building, and Preserving Affordable Housing.* (Chicago: American Planning Association Planners Press, 2009), 5.
[9] William F. Delvac. *Affordable Housing Through Preservation: A Case Study Guide to Combining the Tax Credits.* (Washington D.C.: U.S. Department of the Interior, 1994), 6.
[10] Mayor's Affordable Housing Group. *Comprehensive Housing Strategy for the City and County of Honolulu*. Final Report. (Honolulu, 2008), 23.
[11] Kevin Carney, interview by author, Honolulu, HI. November 18, 2010.

ensure those who need housing will get it and prevents homeowners from making money at the expense of tax payers.[12]

For the past few decades, advocates for quality affordable housing design have argued for low-rise, high density affordable housing that can come in the form of low-rise apartment complexes, row- or townhouses, or garden apartments. This is because these types of housing are more able to include the humanistic qualities of single-family homes (such as private entrances) with the economic benefit of higher density.[13] Majority of the affordable or low-income housing units constructed in urban Honolulu are low-rise apartment complexes such as Kukui Gardens and are more or less located in the Kalihi district.

Image 1. Examples of Assisted Housing in Honolulu

- Kukui Tower (Kalihi, Oahu)[14]
- Kukui Gardens Makai (Liliha, Oahu)[15]

[12] Chris Lee, interview by author. Honolulu, HI. November 23, 2010.
[13] Sam Davis, *the Architecture of Affordable Housing.* (Berkeley: University of California Press, 1995), 16-17
[14] EAH. "Kukui Tower." <http://www.eahhousing.org/download/KTfam_verticleshot.jpg> (accessed March 2, 2012).
[15] EAH. "Kukui Gardens." <http://www.eahhousing.org/download/KGM2_June2010.jpg> (accessed March 2, 2012).

Moderate Income

Under both federal and City and County of Honolulu definitions, households who earn between 80-120% of their area's median income are considered to be "moderate income" households. In recent years, due to an economic recession and the housing bubble collapse, the moderate income bracket has been expanded to include household incomes up to 140% of Honolulu's area median income.[16]

The State of Hawaii has recognized that more 'moderate income' households (also referred to as 'gap group') are in need of housing that is affordable to their income level since they do not qualify for assisted housing or government assistance nor do they earn enough to afford market rate housing. Some areas such as Kakaʻako recognize the need for housing for this gap group and have established housing requirements that are 'reserved' for those who earn below 140% of Honolulu's AMI.

Affordable/Workforce Housing

For Hawaii, affordable/workforce housing is generally intended to be affordable for moderate income households who earn less than 140% of Honolulu's area median income. Workforce housing is housing that is aimed to be affordable to support local employees so that they can live in the communities where they work. In Hawaii, workforce housing is generally provided to be affordable for two-wage earning households in service and government industries such as teachers, professors, police officers, firefighters, nurses, etc. Generally, affordable/workforce housing is located outside of Honolulu's urban district and incurs substantial transportation costs if they work within urban Honolulu.[17]

Image 2. Affordable Housing in Ewa Beach[18]

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[16] Mayor's Affordable Housing Group. *Comprehensive Housing Strategy for the City and County of Honolulu*. Final Report. (Honolulu, 2008), 8.
[17] Mayor's Affordable Housing Group. *Comprehensive Housing Strategy for the City and County of Honolulu*. Final Report. (Honolulu, 2008), 8-9.
[18] Prudential Locations. "Top Ten Most Affordable Homes on Oahu." February 29, 2012 <http://www.prudentiallocations.com/news/featured-listings/top-ten-most-affordable-homes-on-oahu.aspx> (accessed April 30, 2012).

The exception is in the Kaka'ako Community Development district, located in urban Honolulu, where the Hawaii Community Development Authority (HCDA) has established regulations that require residential developers to dedicate 20% of their residential floor area to be rented or sold to households earning below 140% of Honolulu's AMI. This is referred to as *reserved housing* a term coined by the HCDA.[19]

Image 3. Examples of Reserved Housing in Kaka'ako, Oahu: Kamakee Vista (L)[20] & Kauhale Kaka'ako (R)[21]

Another type of affordable or workforce housing is "employer-assisted housing." This type of housing is affordable housing that is provided by a company for its employees in order to attract and maintain quality employees. Employer-assisted housing in Hawaii is largely utilized by resort developments that are otherwise isolated from residential areas, resulting in long commutes for its employees. On the Big Island of Hawaii, hotel resorts are required by the County to provide housing for its employees since there are few means of public transportation available for hotel workers. Some notable examples of employer-assisted housing are La`ilani at Kealakehe which is part of the Mauna Lani Resort on the island of Hawaii and Kamakoa Vistas at Waikoloa on the island of Oahu.

[19] State of Hawaii, Department of Business, Economic Development and Tourism, *Repeal of Chapter 15-22 and Adoption of Chapter 15-217 Hawaii Administrative Rules.* (Honolulu, 2011), ch. 217. Sec. 57, 217-53.
[20] Hawaii Community Development Authority. "Kamakee Vista." http://hcdaweb.org/kakaako/projects/kamakeevista2.JPG (accessed March 2, 2012).
[21] Hawaii Community Development Authority. "Kauhale Kakaako." http://hcdaweb.org/kakaako/projects/kauhalekakaako.JPG (accessed March 4, 2012).

Image 4. Example of Employer Assisted Housing: Kamakoa Vistas at Waikoloa (Waikoloa, Big Island)[22]

[22] ArchInnovations. "MVE Pacific Creates Homes for Hawaii's Workforce." http://www.archinnovations.com/images/stories/Projects/MVE_Kamakoa/MVE_Kamakoa_02.jpg (accessed March 2, 2012).

Market Rate Housing

Market rate housing is housing that is intended for households earning above 140% of Honolulu's area median income. According to the Mayor's Affordable Housing Advisory Group, households earning more than 205% of Honolulu's AMI are required to purchase a median priced residence in Honolulu, which equaled $600,000 in 2008.[23]

Market rate housing can take all types of forms from high-rise apartments or condominiums to single-family homes. In times of economic growth, incomes generally rise, theoretically enabling some households to afford more expensive housing.

Unfortunately, with the rising costs of construction, new homes are likely to be out of reach for lower income families. Some developers speculate that ample amounts of new housing will make the existing housing stock affordable through filtering which is the process of market rate housing becoming affordable as affluent families move from their old homes into newer buildings that are being constructed. This concept is known as filtering. The notion of filtering in housing generally applies to rental units. Alan Mallach, an author of various books on urban planning, housing, and community development, believes that the nature of consumer preferences tends to limit filtering from being effective. Affluent renters tend to occupy cheaper housing, taking away housing resources from lower-income families who cannot afford to occupy the newer, more expensive units, leaving them vacant and these families without housing.[24] It is for this reason that many housing projects have reserved units that are available to those who meet certain income limit requirements. Table 3 summarizes the abovementioned definitions to Honolulu's area median income based on HUD's income limits for the 2011 fiscal year. The income limits for low- and very low-incomes have already been adjusted by HUD in order to take into account Honolulu's high housing cost. Furthermore, the table illustrates the highest amount each income bracket can afford to spend on housing based on the definition of affordability mentioned above. The last column identifies the housing types and assistance each income group qualifies for in Honolulu.

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[23] Mayor's Affordable Housing Group. *Comprehensive Housing Strategy for the City and County of Honolulu*. Final Report. (Honolulu, 2008), 9.

[24] Alan Mallach. *A Decent Home: Planning, Building, and Preserving Affordable Housing.* (Chicago: American Planning Association Planners Press, 2009), 15-17.

Image 5. Example of Market Rate Housing: Capitol Place[25]

[25] "Capitol Place." HICondos.com. <http://www.hicondos.com/img/CapitolPlace/CapitolPlace.jpg> (Accessed May 5, 2012).

Table 3. Summary of Hawaii Income Limits (FY 2011)[26]

	INCOME LIMIT (ADJUSTED FOR 4-PERSON HOUSEHOLD)	ASSUMED ANNUAL HOUSING EXPENDITURES	QUALIFIED HOUSING OR ASSISTANCE
Very Low Income Less than 50% of AMI	$51,500	$15,450	Public Housing, Assisted Housing, All Section 8 Programs
Low Income Between 50-80% of AMI*	$82,400	$24,720	Public Housing, Assisted Housing, All Section 8 Programs, HOME Investment Partnerships
Moderate Income Between 80-100% of AMI**	$82,700	$24,810	Reserved Housing, Workforce Housing, Tax-exempt Mortgage Revenue Bonds, Below-Market Interest Rate (BMIR) rental program, National Homeownership Trust Act
Gap Group 100% - 140% of AMI**	$115,780	$34,734	Tax-exempt Mortgage Revenue Bonds (only up to 115% AMI), Reserved Housing

* HUD Income Limits for Low-Income do not necessarily reflect 80% of Honolulu's AMI but is calculated at 1.6 times Honolulu's four-person very low-income limit.[27]

**Because HUD does not provide income limits for moderate or gap group incomes, it is assumed that these income limits are to be calculated based on the 80-100% and 100-140% of Honolulu's area median income respectively. These percentages are determined by HUD for moderate income and the Mayor's Affordable Housing Group for Honolulu's Gap Group.

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[26] Table calculated from data listed in U.S. Department of Housing and Urban Development. *FY 2012 Income Limits Briefing Material.* December 1, 2011. http://www.huduser.org/portal/datasets/il/il11/IncomeLimitsBriefingMaterial_FY11_v2.pdf (Accessed January 26 2012), p. 24, 28.

[27] Ibid, 8.

As mentioned earlier in this document, the affordability of Honolulu's housing supply is almost segregated in a way that only the rich and the poor (with government assistance) are able to afford to live in the city which is particularly problematic because it creates a certain amount of social and economic tension.

Honolulu cannot continue to rely too heavily on government support for housing. Doing so puts additional burdens on State and local budgets, inevitably raising everyone's cost of living via taxes. To create housing that is affordable without (or with limited) government subsidies should be the ultimate goal. Realistically, to be able to do so for very low- or low-income families is a tremendously daunting task – one that may be impossible at this point in time. It is therefore the goal of this project to target the moderate income and gap-group income households.

1.2 Making Housing Affordable

Creating housing without government assistance means that in some form or another, costs need to be cut. Because this project attempts to provide a means of increasing the supply of available affordable housing, a look at costs associated with providing affordable housing is necessary to illustrate key cost factors that limit production and maintenance of housing affordability.

Capital Costs

Capital costs are the initial costs that a project will incur and includes such expenses as land acquisition, infrastructure, planning, materials, labor, design services, and entitlements. The capital costs of a project are often what majority of people are most sensitive to. The following sections describe the major types of capital costs associated with a typical residential development project and current strategies used by local housing developers to reduce these costs.

Land & Entitlements

Land is the undisputed culprit of high housing costs in Hawaii. Without large amounts of developable land at our fingertips, Hawaii's land prices can sometimes almost double the cost of a home. Ninety-five percent of the State's land is designated as agricultural or preservation land which is considered "non-urban" and therefore, undevelopable for residential use. Variances and changes in zoning can be made, but often times the process is lengthy and ultimately adds additional costs to project. Furthermore, there are several major landowners that hold a large percentage of available land such as Kamehameha Schools, Castle and Cooke, Inc., the Harry and Jeanette Weinberg Foundation and the Queen Liliuokalani Trust.

Many of the new affordable homes built by developers are part of a public benefit agreement made with counties in exchange for rezoning agricultural land for residential use. These agreements tend to require 20-30% of the newly developed homes to be affordable.[28] Required

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[28] Andrew Gomes. "Affordable Housing." *Honolulu Advertiser.* June 10, 2007.

employee-assisted housing on large resort projects has already become increasingly common in order to support Hawaii's tourism industry. While these public benefit agreements have yet to be implemented in the commercial sector, the State Land Use Commission has already begun mandating some affordable housing requirements especially on expansions to business and industrial parks on some of the outer islands.

Community land trusts (CLTs) are one method of addressing the high cost of land acquisition in Hawaii. CLTs are democratically-controlled non-profit corporations that acquire and hold land but sell off residential and community buildings which are on the land, minimizing the cost of land in housing in order to make it more affordable.[29] Most of Hawaii's land trusts are conservation trusts which are formed to acquire and protect open space and agricultural land; however Na Hale O Maui and the Kohala Community Land Trust are some CLTs aiming to provide affordable housing for their respective communities. The Kamakoa Vistas affordable housing project at Waikoloa on the Big Island also utilizes a community land trust.

Urban infill development is another way to reduce land costs since high-density urban development condenses housing on an efficient amount of land and infrastructure. Depending on its size, suburban development occupies large tracts of land and requires a significant amount of construction of roadways, utility lines, and additional community support facilities such as schools, parks, fire and police stations. All of this amounts to high costs in addition to the construction of individual dwelling units. In urban infill projects, the roads, utilities, and community facilities are already in place, reducing or eliminating these costs from the construction budget. However, urban infill projects are also subject to more neighborhood and public opposition especially in the immediate area of the project location which can tie up a project or add requirements or conditions (such as upsizing utilities or improving existing infrastructure) to appease opponents. In Honolulu, some of these requirements are mandated by government rules and regulations.

Many affordable housing advocates in Hawaii often mention the role of government and political policies as a major roadblock in affordable housing development. In general, Hawaii's government has been wary of overdevelopment and its land use policies are said to be aimed at preserving Hawaii's environment and quality of life. As a result, developers must also incur costs for multiple studies, infrastructure, and government-mandated project changes based on requirements from Honolulu's development plan, comprehensive zoning code, subdivision code, grading code, and building code.

Materials

The cost of building materials definitely has an impact on the cost of housing and is often the one of the first things to be analyzed for cost-efficiency in any building project. Like all other goods in Hawaii, construction materials cost more in Hawaii due to its proximity away from

[29] Tom Peterson. "Community Land Trusts: An Introduction." PlannersWeb: Planning Commission Journal. Summer 1996. http://www.plannersweb.com/articles/pet112.html (accessed September 13, 2010).

manufacturing areas. Hawaii is an island economy with limited resources in terms of raw building material and most of the building materials for these houses have to be shipped from the mainland at some point or another. Transportation costs for non-local materials add to the final cost of construction for many projects. La Croix also states that high inventory costs (which result from the distance from suppliers forcing retailers to keep extra high inventory levels) also contribute to high construction costs.[30] From early on, architects in Hawaii have been trying to find new and innovative ways of building with locally available materials as a way of reducing construction costs.

One way to reduce material costs is to use cheaper materials – perhaps a lower grade material or a cheaper alternative. Most times, however, using a cheaper material will result in a poorer performing product than the original. For example, plastic laminate floors are considered to be high-performing alternatives to many products since they can imitate the look of natural materials such as wood (to some extent) for a fraction of the cost. The trade-off however is that damage to laminate flooring is irreparable. If there is a chip or a scratch in the laminate or if the finish begins to delaminate from its core, the entire piece of flooring must be replaced whereas with solid wood floors, the floor can usually be sanded and refinished without removing anything.

Reusing building materials is one way that Hawaii can utilize what resources are currently available on the islands in order to reduce overseas transportation costs. There are currently several companies in Hawaii that are involved with recycling asphalt and reinforced concrete for paving and roadways, purchasing and processing of structural steel and scrap metals, and crushing glass for cement asphalt paving. Additionally, there are a few deconstruction contractors such as Re-Use Hawaii that deconstruct homes and warehouse the salvageable materials for resale.

Reducing the amount of material used in a building is another way of reducing material costs during construction. This can either be done by reducing the size of a unit (e.g. micro-housing, compact living) or by utilizing construction methods that minimizes the amount of waste created on site (e.g. optimum value engineered framing methods).

Micro-housing or compact living is one movement in housing that fights against Americans' obsession with excess. In American culture, the popular opinion is that bigger is better, at least when it comes to space. A big house or apartment is often considered a visible reward for the hard work one has done throughout one's life and a symbol of our status. Micro-housing and compact living essentially try to break this stereotype and argue for design solutions that make small spaces appear larger, more elegant, and still accommodate the functional needs of its inhabitants.

[30] Sumner J. La Croix, "Cost of Housing: Can government make housing affordable?" *The Price of Paradise: Lucky We Live Hawaii?* Edited by Randall W. Roth, (Honolulu: Mutual Publishing, 1992), 137.

Optimum value engineered framing methods (OVE) are techniques used in framing that minimize construction waste without compromising structural integrity. These techniques include utilizing two-stud corner framing with drywall clips, eliminating headers in non-load bearing walls, increasing floor joist, rafter, and wall stud spacing to 24 inches, and using single top plates with in-line framing to transfer loads directly.[31]

Labor

The cost of labor is a major consideration that needs to be taken into account. Complex construction methods and complicated designs such as curved walls and unique or innovative features often results in higher labor costs. Additionally, buildings that require a lot of heavy components may require cranes and other special equipment to lift these components into place which ultimately adds to the final cost of construction. Such equipment often requires specialized operators that are often paid more than the typical construction worker.

Prefabrication is one method of addressing labor costs on construction projects. Prefabrication is the manufacturing of buildings or building components in a factory or plant that is then shipped to the project's site where it will be assembled. Labor costs are generally reduced through prefabrication because workers who are assembling the prefabricated components off-site are considered to be assembly line workers rather than construction workers, which allow prefabrication companies to hire them at a lower cost.

Construction labor unions generally have a problem with prefabrication in construction because it reduces the amount of work available for skilled laborers. There are various levels of involvement for construction workers within prefabricated housing. In particular, skilled labor is still needed to build the building's foundation as well as on-site assembly of components for many modular and componentized prefabricated systems.

Sweat equity is another method of eliminating or reducing labor costs since it involves uncompensated or volunteer labor as "payment" toward homeownership. Habitat for Humanity is an ecumenical Christian ministry that utilizes sweat equity to provide affordable housing to low-income families. It is probably one of the most familiar examples of sweat equity used to make housing affordable in Hawaii.

One example of sweat equity being particularly successful was in the Delancey Street housing project in San Francisco that was designed by Howard Backen. The future residents of the project were former substance abusers and felons who entered into a cooperative arrangement with the architect and a local contractor. The process involved selecting certain features that required a specific skill or trade and training the residents to fabricate these elements of the project design (such as the wrought iron handrails used throughout the project that the tenants wanted). The residents of Delaney Street housing were able to obtain the features in the

[31] U.S. Department of Energy, Energy Efficiency & Renewable Energy. "Optimum Value Engineering." *Best Practice Guide.* http://www.eere.energy.gov/buildings/building_america/pdfs/db/35380.pdf (accessed February 15, 2012).

building that they wanted as well as acquire marketable trade skills. Furthermore, they were able to take pride in their work, providing a sense of responsibility to help preserve the quality and condition of the housing project they helped create.[32]

Image 6. Delancey Street Housing (SOMA District, San Francisco, California)[33]

In Hawaii, sweat equity primarily occurs through self-help housing programs such as Habitat for Humanity and the Nanakuli Housing Corporation. Through the Habitat for Humanity program, homes are sold for no profit to partnering families through a joint-venture that requires the family to contribute 500 hours to construction labor in order to help reduce the cost of construction for the homes. The average cost of the Habitat homes on Oahu is $90,000 which the families are able to take out no-interest mortgages on over a fixed period (typically $600 monthly payments).[34] While this is one method of eliminating labor costs to providing affordable housing to qualifying families on Oahu, many of the projects are single-family residences.

[32] Sam Davis, *The Architecture of Affordable Housing.* (Berkeley: University of California Press, 1995), 73.
[33] Centers and Edges. "A well designed affordable housing project." http://centersandedges.org/wp-content/uploads/2011/01/06c-DelanceyStreet-SF-Taecker-1024x725.jpg (accessed March 2, 2012).
[34] Honolulu Habitat for Humanity. "How Families are Selected." http://www.honoluluhabitat.org/?page_id=63 (accessed February 15, 2012).

Image 7. Habitat for Humanity Honolulu - Vasconcellos Home[35]

Carrying Costs

Carrying costs are costs associated over the life span of the building. These include operational costs, maintenance cost, and utilities costs. According to Kevin Carney, Vice President of EAH (an affordable housing development and management company for Hawaii and California), maintenance for their affordable housing projects can cost $6,000-$7,000 annually per unit, depending on the site.[36] These costs include those for staff, garbage collection, water, sewer and utilities. Generally, the monetary savings provided by many green-building design strategies apply to the carrying costs of a building, specifically physical building maintenance, cleaning, and utilities use.

Durability & Maintenance

The issues of durability and maintenance are key factors in the perception of affordable housing in Hawaii and are aspects that architects actually have a significant amount of control over through design.

Deterioration of buildings is often a tell-tale sign of hardship to the public and can lead to a devaluation of property value, especially if an entire area consists of dilapidated buildings and poorly maintained structures. This is generally true for all buildings, not just housing or low-income housing projects. Adding this to the already preconceived prejudices held against low-income communities and the project becomes a vehicle of further stigmatization for its residents and its community. This is why it is particularly important for affordable and low-income housing be concerned with the upkeep and maintenance of their buildings beyond aesthetic reasons. However, because funding for building affordable housing projects are limited, government tends to severely scrutinize the cost of design and as a result, often times the quality and durability of an affordable housing project suffers.

To illustrate the importance of maintenance on affordable housing, affordable housing architect Sam Davis describes the affordable housing project of Acorn in Oakland, California. The project had all the architectural and development ingredients of a quality affordable housing project including support from a politically strong community group, access to transportation and jobs, high-density and low-rise units, courtyards, mixed-income and culturally diverse residents, schools, community facilities, and even a panelized construction method. Once constructed, the project received vast amounts of praise and recognition including awards from HUD and the AIA. However, several factors led to an ultimate failure for the project, including several design decisions.

First, the project's modern, cubist aesthetic were viewed by the community as sterile and monotonous leaving some of its residents unable to identify with it. Also, because of this

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[35] Honolulu Habitat for Humanity. "Vasconcellos Family Home." http://www.honoluluhabitat.org/wp-content/uploads/2010/12/P4040250.jpg (accessed March 2, 2012).

[36] Kevin Carney, *Vice President, EAH Housing (Hawaii).* Interview by author. November 18, 2010.

aesthetic, and for budgetary reasons, functional elements such as rain gutters on sloping roofs and overhangs on its flat roofs were eliminated, resulting in water infiltration to the units. The project's financial sources were non-local, which exacerbated the overall lack of attention to maintenance. The project ultimately was considered to be a failure for various reasons besides design.[37]

There are generally two approaches to addressing the wear and tear of a building. The first is to design for permanence, which is how many older historic buildings were designed. Durable materials such as stone, concrete and masonry were often used to design buildings that were intended to last for centuries. This type of approach to design is typically used for civic buildings, monuments and other buildings meant to essentially last forever. This also involves a fair amount of diligence from maintenance staff in order to ensure that what was built remains in working and/or presentable conditions.

The second approach is to design buildings that have an expected lifespan. The assumption behind this type of construction is that the building will be replaced at the end of its useful life. The development of more recent construction methods and the focus on capital costs in the housing industry has led to more homes built under this assumption.

The third approach is sort of a hybrid of the two previous approaches in which a building is designed in layers with each layer having a different expected lifespan than the others. The benefit of this approach is the structure of the building is designed to be permanent while its contents have the ability to change over time. This approach is primarily used in commercial/office buildings where tenants and employees are expected to change. It is also the basic approach in flexible housing design which will be discussed later in this chapter.

Utilities

Not only do homeowners and renters absorb costs of the building but they must also pay for using the building which includes the use of electricity, water, and fuel. With the recent increase in technological developments for energy efficiency and water efficiency, many developers (including affordable housing developers) are particularly interested in incorporating sustainable design and technologies into their projects both for marketing reasons as well as energy and cost savings.

The State of Hawaii has produced several homeowners' guides that provide recommendations for homeowners to reduce their consumption in order to reduce their water and energy bills. Switching incandescent light bulbs to compact fluorescent bulbs, solar water heating, passive cooling (or heating) strategies and installing photovoltaic (PV) systems will all work toward reducing a home's energy consumption and ultimately result in savings on electric bills. Likewise, water catchment systems and installing low-flow or low-flush water fixtures result in savings on water bills.

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[37] Sam Davis. *The Architecture of Affordable Housing*. (Berkeley: University of California Press, 1995), 118-125.

Housing developers are now using these environmentally-friendly features as marketing tools for their projects and affordable housing developers are also looking toward their benefits in terms of long-term savings. EAH, a prominent affordable housing developer and manager in Hawaii and California is trying to incorporate various types of environmentally friendly and healthy design elements into their projects. They have worked with the Hawaiian Electric Company (HECO) to provide $28,000 worth of compact fluorescent bulbs for distribution to residents of their projects which would reduce each tenant's energy consumption. In addition to retrofitting renewable energy technologies onto some of their older projects, one of their smaller projects in California is designed for people who are especially sensitive to chemicals.[38] It therefore stands that 'green building' is a worthwhile consideration for housing for all income levels, and not to be viewed as a luxury.

[38] Kevin Carney, *Vice President, EAH Housing (Hawaii).* Interview by author. November 18, 2010.

1.3 Social Issues of Concern for Affordable Housing

Concerns regarding wealth, poverty and social status have always been of concern to societies in general, no matter how suppressed it might appear to be in contemporary American society. Reflections of status and wealth are inherently expressed in housing and its architecture.

Assisted housing and affordable/workforce housing are often designed with cost being the number one concern that directs decision-making. But one of the problems that have occurred as a result of cost-centric decision-making is the construction of sterile and sometimes dysfunctional housing projects. This, in turn, can exacerbate undesirable behavioral outcomes from residents or their neighbors. Therefore, it is important to discuss social issues of concern when designing affordable housing.

Substandard Housing & Housing Quality

With the implementation of building codes in the United States, fewer low-income families today suffer from substandard housing than they have in the past. Still, a common belief – often shared by government officials responsible for providing funding to subsidize projects – believe that affordable housing should provide the bare minimum essentials for families to live in; no frills and no unnecessary features should be considered when in order to reduce the amount of construction costs.

The generally accepted basic requirements for minimally acceptable housing include four solid walls, electricity, plumbing (including flush toilets, bath or shower, and hot and cold running water), a complete kitchen, adequate heat in cold weather and no hazards such as lead paint or asbestos. In 2005, the American Housing Survey found that most lower-income households lived in homes that met these basic requirements. The study found that 6% of all housing units in the United States had moderate to severe deficiencies while 13% of all low income families lived in physically deficient housing.[39] Physical deficiencies include open cracks or holes in walls, floors, and ceilings; external deficiencies such as sagging roofs, cracking foundations, or missing exterior siding; and infestation of pests such as mice or rats.

Tenements were one of the earliest types of affordable housing in the modern housing movement, which, for the United States began during the second half of the 19th century.[40] These buildings were often overcrowded, poorly ventilated, and unsanitary. They were often located near clogged and overflowing open sewers and heaps of garbage and infested with roaches and rodents, causing numerous health and safety issues for their residents. These conditions legitimized the reformists' desire for tenement house codes which aimed to improve the physical living conditions for the poor.

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[39] Alan Mallach. *A Decent Home: Planning, Building, and Preserving Affordable Housing.* (Chicago: American Planning Association Planners Press, 2009), 2.

[40] Alan Mallach. *A Decent Home: Planning, Building, and Preserving Affordable Housing.* (Chicago: American Planning Association Planners Press, 2009), 29.

While the implementation of codes and regulations formed with the intent to protect low-income occupants from poor construction, over time, politics have influenced the implementation of some codes made solely to protect the interests of a specific group or industry which can end up increasing costs with no real benefit. Zoning ordinances that exclude higher-density housing from some communities is an example of such policies.[41] This quite often is the case in Hawaii where we have many zoning ordinances and special design district regulations that limit building heights in order to preserve *mauka* to *makai* views, limit the types of materials being used, and determine a building's architectural character in an attempt to maintain Hawaii's sense of place.

Standardization and replication of buildings are two common ways to lower housing costs. However, San Francisco based affordable housing architect Sam Davis believes that while standardization does produce efficiencies, the "cookie-cutter" approach was what ultimately doomed so many public housing projects historically. Standardization and replication of entire buildings may have the effect of residents feeling removed from their homes and being unable to identify with it. As Davis says, "the key [to designing successful affordable housing] is to find means of including architectural variety and diversity within recurring building systems."[42]

Increasing concerns for affordable housing quality and increasing needs for market-rate housing affordability has resulted in a narrowing gap between the construction costs for market-rate and affordable-housing. As market rate housing continues to find cost-effective ways to provide housing while maximizing profit, building codes and other regulations continue to demand more of affordable housing, eventually raising construction costs. Today there is not much difference between the cost of building market rate housing and building affordable housing which is why affordable housing projects often require government subsidies, various types of donations (land, labor, materials, etc.), or other means of assistance in order to truly be affordable for low-income families and households.

[41] Sam Davis. *The Architecture of Affordable Housing.* (Berkeley: University of California Press, 1995), 4.
[42] Sam Davis. *The Architecture of Affordable Housing.* (Berkeley: University of California Press, 1995), 4

Overcrowding

Overcrowding occurs where either limited financial resources or a limited supply of affordable housing force families and households to double up or occupy units that are too small in order to avoid homelessness. The federal government defines overcrowding as more than one person per room in a housing unit, while severe overcrowding is defined as more than one and a half persons per room in a unit.[43]

Overcrowding generally affects the well-being and privacy of its residents. If overcrowding occurs with residents that are unrelated or strangers, living conditions can become especially uncomfortable and at times unsafe.

Poverty Concentration & Regional Equity

However, improved living conditions for low-income and affordable housing residents have in some ways been resisted. There are some who feel that it is unfair for low-income families and households to occupy newer and nicer housing than those who have higher incomes, higher education, pay more taxes but are unable to qualify for assisted housing and must live in lower-quality housing. In response to Dan Nakaso's article "Future of Low-Cost Housing Uncertain" (posted October 1, 2010, on *Honolulu Star-Advertiser.com*)*,* Oahumike (pseud.) made the following comment (posted October 2010), illustrating this opinion:

> *"It is so unfair that I have to wake up at 5am and go to work all day, only to have my money taken away from me to pay for someone else's house. I have never taken a dime from anybody to get to where i am today. Why are these people automatically entitled to MY dime? To date I've paid for my own rents, mortgages, food, medical bills, utilities, tuition, and for my children. If I had it my way, I wouldn't give one red cent to these people - their problems are not mine, and the money they take from me belongs to my children."*

Although this example is an extreme take on this opinion, it is not without warrant. There are individuals who take advantage of public services such as welfare, unemployment benefits, and public housing without making an effort to work towards getting a job or lessening their "burden on society." Some individuals in poverty may find themselves there because of drug use or turn to criminal activities to make ends meet. Because of these individuals, the majority of low-income families must often endure these prejudices from the rest of the public.

Suburbanization in the United States has led to further segregation of economic classes. Wealthier families tend to congregate together and also tend to live in exclusive central-city neighborhoods and more distant suburbs since they generally have more available means of travel. Concentration of poverty often occurs in older cities, central cities, and inner suburbs

[43] Rooms include bedrooms, living rooms, kitchens, separate dining rooms, and other rooms except bathrooms, alcoves and foyers. (Mallach 2009, 7-8)

that lack social, economic and fiscal resources needed to give residents minimum opportunities and a decent quality of life.[44]

Poverty concentration will often stigmatize an area with a strong negative association as well. Most times, concentrations of social ills either develop or develop from concentrations of poverty. These social problems include a lack of private sector business activity which leads to an increase in the cost of goods and services for residents, limited job networks and access to employment, limited educational opportunities, high occurrence of crime, diminished mental and physical health of residents, deterioration of local government services and increase political and societal fragmentation.[45]

Because of its geographic size and high housing demand, Honolulu has the largest number of public housing projects funded by the Hawaii Public Housing Authority (HPHA). Twenty-five of these projects are located in the Kalihi district, an area often negatively associated with crime and decay due in part to the high concentration of assisted housing projects. A majority of the projects have been built over 20 years ago and have not been well maintained, adding to the stigmatization of the Kalihi community.

The issue of poverty concentration is not only an issue concerning the location of the project's site or the number of low-income residents a particular project houses. The architectural design of an affordable housing project can work for or against the social integration of its residents as well.

During the 1950's, public housing commonly came in the form of high-rise apartment blocks – an attempt to cram as many units as possible onto a piece of land. This architectural prototype known as "towers in the park" – dense, high-rise towers surrounded by large amounts of open spaces – based on architectural ideologies inherited from Le Corbusier, and became the model for public and subsidized housing projects during this time. However, these projects socially isolated and alienated low-income housing occupants from the rest of the community by physically segregating them with these unplanned, non-functioning open "park" spaces. Beginning in the 1960's and 70's, affordable housing became a means of social activism, done in order to lessen the societal gap between the impoverished and the rest of society. However, this stemmed a desire for protection of property and lifestyle amongst many residential communities and individuals which has become known as "Not In My Backyard" or "NIMBY-ism". Such arguments stemming from NIMBY-ism are basically rooted in concerns for family safety and maintaining property values and are common opposition to many affordable housing projects and/or necessary residential facilities such as half-way houses, transition homes,

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[44] Alan Mallach. *A Decent Home: Planning, Building and Preserving Affordable Housing.* (Chicago: American Planners Association Planning Press, 2009), 21

[45] Berube, Alan and Bruce Katz. *Katrina's Window: Confronting Concentrated Poverty across America*. Washington D.C.: Brookings Institution, 2005.

residential drug treatment centers, and foster homes.[46] Though most people agree that these facilities and projects are necessary to benefit society, they do not want to bear the consequences personally and believe they should be located elsewhere. Recently, advocates for affordable housing have been pushing for affordable housing to be integrated and appear to be indistinguishable from market-rate housing. This is done in an attempt to minimize areas of high poverty concentration that result in isolation and segregation of the poor and provide desirable yet affordable neighborhoods.

It is important to note that affordable housing is not just for the poor. Though affordability has typically been measured based on the traditional 4-person household consisting of dual incomes, today's family structure comes in a variety of forms. Demographic groups that also need affordable housing besides the poor include families with single parents, seniors on fixed incomes, people with disabilities, recent college graduates and the newly unemployed.

Economic Competitiveness

As employment provides the income for many low-income and affordable housing residents, it is important to consider the locations of job centers relative to residential neighborhoods. "Affordable housing, by its nature, is housing for people who have fewer resources and fewer options outside the home than more affluent families. As such, its residents are likely to be more dependent on their immediate environment, both the individual dwelling unit and the building or complex of which it is a part, than are the residents of more expensive housing, who are more mobile and more able to pay for entertainment and travel outside the community."[47]

Unfortunately in Hawaii, especially on Oahu, there is a huge distance between residential areas and its job centers. Hawaii is extremely car-oriented with limited modes of public transportation. As development of Honolulu's mass-transit system progresses, transit-oriented development (TOD) has been a topic of interest for many developers and people in the building industry. This provides many opportunities to locate affordable housing closer to public transportation hubs and eventually employ strategies that encourage smart-growth development.

With the movement of the middle class into suburbia, more and more jobs are moving with them. Therefore, it is necessary to provide affordable housing not only in urban environments but in the suburbs as well to sustain job centers.

Safety

Resident safety is a major concern for all housing developments but a critical one for affordable and low-income housing developments as there is an unavoidable perception of danger associated with those in poverty. All individuals need to feel safe in their home in order to be

[46] Sam Davis. *The Architecture of Affordable Housing.* (Berkeley: University of California Press, 1995), 17.
[47] Alan Mallach. *A Decent Home: Planning, Building, and Preserving Affordable Housing.* (Chicago: American Planning Association Planners Press, 2009), 54.

comfortable and likewise communities need to feel safe in order to avoid further segregation of economic status. Sometimes low-income and affordable housing projects are constructed in areas of high crime and drug activity, in which safety is a critical issue for all residents. Even in areas with less crime, it is still important to ensure a high level of comfort particularly for vulnerable populations such as the elderly, disabled, or families with young children. It is important to maintain a sense of security within residents and community in order for a project to be beneficial.

There are two basic principles that have emerged for designing for security: surveillance and defensible space.[48] Surveillance is the visual control or monitoring of an environment. Residents need the ability to see or be aware of what is happening around them. Methods of surveillance can include security cameras, alarms, security personnel and motion-detection lights but can also be as simple as being able to see who is coming up your steps or where your children are playing.

Defensible space is the space which a person perceives she has the ability to defend or control and in which she has the right to monitor behavior.[49] It is rooted in the idea of territoriality where a person feels a sense of responsibility for her property and family's security. The idea of defensible spaces does not necessarily end at the end of one's property. According to Oscar Newman, truly successful multifamily housing is able to connect the idea of territoriality to community.

"No individual family in an apartment complex can take responsibility for the security of a complex; indeed, without the cooperation of their neighbors, they cannot exert effective control over any area much beyond the door of their apartment."[50]

A "spatially territorial community" would be able to ensure a communal sense of safety for the entire complex, giving residents a sense of control over areas beyond their individual space. Hierarchy of space from private to public is one way to create these communities.

The ability for residents to be able to identify with their homes is another contributing factor in establishing safety for residents. The Pruitt-Igoe public housing project in St. Louis became uninhabitable because of its concentration of poverty, dangerous common areas, and lack of utilitarian features to address the needs of its residents. There was no hierarchy of space and Oscar Newman commented that "because all the grounds were common and disassociated from

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[48] Alan Mallach. *A Decent Home: Planning, Building, and Preserving Affordable Housing.* (Chicago: American Planning Association Planners Press, 2009), 70.
[49] Alan Mallach. *A Decent Home: Planning, Building, and Preserving Affordable Housing.* (Chicago: American Planning Association Planners Press, 2009), 70.
[50] Alan Mallach. *A Decent Home: Planning, Building, and Preserving Affordable Housing.* (Chicago: American Planning Association Planners Press, 2009), 71.

the units, no one could identify with them."[51] In this particular project, the lack of consideration for its residents led to its common areas often covered in graffiti, broken glass and human waste. Residents did not feel safe in this building and many of the units became vacant over the years. The project ultimately was demolished in 1972.[52]

Returning to the idea of defensible space, one must be especially careful when designing open space for affordable housing developments and take into consideration the availability of public access onto the grounds of the development. Because some members of low-income families are involved in criminal and drug activities, some method of screening or limiting public accessibility is important to incorporate The Acorn development in Oakland, CA which had all the makings of a high-quality affordable housing project exemplifies the importance of a development's porosity and its contribution to the safety for the projects' residents.

Being able to identify with one's own home and community gives residents a higher sense of responsibility for keeping themselves, their families, and their community safe. This is often demonstrated in generally more affluent communities with the implementation of neighborhood watch programs. A similar sense of communal and individual responsibility can be instilled within residents of low-income and affordable housing projects by establishing a sense of pride into the spaces in which they live.

[51] Newman, Oscar. *Creating Defensible Space.* Washington D.C.: U.S. Department of Housing and Urban Development, 10.

[52] Alan Mallach. *A Decent Home: Planning, Building, and Preserving Affordable Housing.* (Chicago: American Planning Association Planners Press, 2009), 55-57.

2.0 EXPERIMENTATIONS IN HOUSING

Historically, experimentation in housing design emerged in response to a dire need for mass housing affordability that went beyond traditional methods of construction. Notions of prefabrication, manufactured and flexible housing essentially all began around the same time period during the First World War in order to provide more affordable and socially responsible ways to construct homes. One of the reasons that these experiments haven't lived up to their promised potential is the fact that the underlying concepts of each branch of experimentation are often taken to the extremes, which results in either a lack in social benefits, affordability, or sustainability.

The idea of prefabrication has promised significant cost savings based on labor cost reduction and standardization, but it has yet to be used in a wide-spread manner. This has partially to do with the inherent inflexibility and lack of customization that some forms of prefabrication entail. Flexible housing, on the other hand, promised similar cost savings with the added element of introducing user control. Unfortunately the concept of flexible housing hasn't become mainstream yet either partially because users did not understand how they were able to modify their own homes.

It becomes evident that perhaps a hybrid of these approaches is needed to find success. To do so requires a closer look at some of the benefits and shortcomings of each proposed approach to housing construction in order to determine what a fitting solution for Honolulu's urban housing might be. The following chapters illustrate some of the major experimentations in housing, the premises behind it, and some case studies that illustrate successful (and unsuccessful) examples of how the concept might be used (or discouraged).

2.1 Prefabrication and Panelization

Prefabrication in the construction industry is a method of standardizing buildings and building components, which is commonly thought to be one of the easiest ways to reduce construction costs and utilize materials more efficiently. The scale of prefabrication in housing can range from the prefabrication of individual components such as roof trusses and panelized wall systems to entire houses that can be transported from the manufacturing plant to the building site.

Background

Prefabrication in the housing industry is not a new idea by any means. Heavy experimentation in new methods of housing construction and housing types occurred during the early twentieth century as a result of the devastation of housing stock from the two world wars. Prefabrication and standardized construction for housing emerged at this time as a result of the need for rapid and inexpensive housing solutions.

Industrialization played a huge factor in the development of prefabrication in housing. Le Corbusier wrote an essay in 1919 that compared automobile, ship and airplane construction to the future of housing construction. In that essay, he challenged architects to find more efficient, streamlined solutions for the construction industry utilizing industrial and factory assembly processes to create housing for the masses. His focus was on using factory-made standard materials that were produced by the industrial processes being used at the time.[53]

Prefabricated housing especially began to gain interest from architects in the United States during the late 1960s. In 1969, the HUD launched Operation Breakthrough which was a government attempt to jump-start a massive factory-produced housing effort. The project was ultimately considered a failure, in part because the program was directed toward innovative production techniques and new materials, oversimplifying housing into a production problem without social components. As a result, the demonstration projects that were constructed did not create a sustainable housing market that encouraged industries to invest in housing-manufacturing facilities.[54]

Factory-built housing in the U.S. has typically been focused toward achieving a mass production of the single-family house. However, Europe has particular success in industrialization in multi-family housing production after World War II since the amount of devastation incurred on its housing stock during the war required quick rebuilding. Europe's historic urban tradition of development also provided the foundation for more experimentation in mid- and high-rise housing construction including experimentation in developing adaptable multi-unit housing. Europe's development in prefabricated building components at this time consisted primarily of

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[53] Fredrick Hong, "Modern Housing Solutions for Hawaii: utilizing prefabrication technologies to develop high-quality urban housing in Hawaii." (D.Arch diss., University of Hawaii at Manoa, 2008), 34-36.

[54] Sam Davis, *the Architecture of Affordable Housing.* (Berkeley: University of California Press, 1995), 28-29.

precast concrete walls and slabs that were produced in factories and lifted onto the site with cranes.

Levels of Prefabrication

There are several types of prefabricated homes being experimented with today including manufactured or mobile homes, modular homes, panelized or componentized homes, and pre-cut homes.[55] The following sections describe each level of prefabrication listed above.

Manufactured & Mobile Homes

Manufactured or mobile homes are entire homes that are built with a permanent support system in a factory and then moved to its final location. Typically these types of prefabricated homes need to include a steel chassis for transportation purposes and are limited in overall width due to transportation laws. Typically, manufactured homes are between 12-14 feet wide which is considered "single wide." The widest a manufactured home can be is 24' which is considered "double wide."

Image 8. Manufactured Home – Living Homes C6[56]

[55] Fredrick Hong, "Modern Housing Solutions for Hawaii: utilizing prefabrication technologies to develop high-quality urban housing in Hawaii." (D.Arch diss., University of Hawaii at Manoa, 2008), 22-29.
[56] Carren Jao. "Green & Affordable Prefab Home Debuts in Palm Springs." *Dwell.com.* http://media.dwell.com/images/645*364/living-homes-c6-1.jpg (accessed March 2, 2012).

Modular Homes

Modular homes are a form of prefabricated housing that utilizes standardized modules that can be assembled in various configurations on site. It can be thought of as prefabricated spaces where as manufactured homes can be considered as prefabricated buildings. Modular homes do not need to include a steel chassis for transportation as they are designed to sit on a permanent foundation that has been constructed on-site.

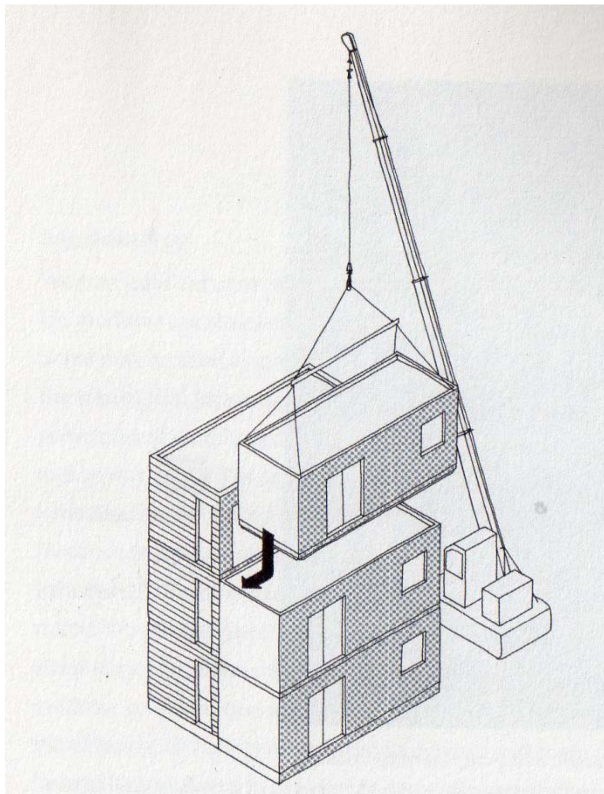

Image 9. Concept of Modular Home[57]

[57] Tatjana Schneider and Jeremy Till. "Figure 6.15: Modules are factory-made and lifted into place on site." *Flexible Housing.* (Amsterdam: Elsevier, 2007), 176.

Panelized or Componentized Homes

Panelized or componentized homes are homes that are made of prefabricated components that are assembled on-site. These components can be anything from wall panels to roof trusses to partitions and floor assemblies that are prefabricated off-site. Componentized homes are the easiest to ship because they can be compactly bundled and shipped on fewer or smaller vehicles. The Packaged House, designed by Konrad Wachmann and Walter Gropius, is perhaps one of the most recognized examples of panelized housing construction in the architectural history of prefabricated housing although it was unsuccessful from a commercial and mass-production standpoint.[58]

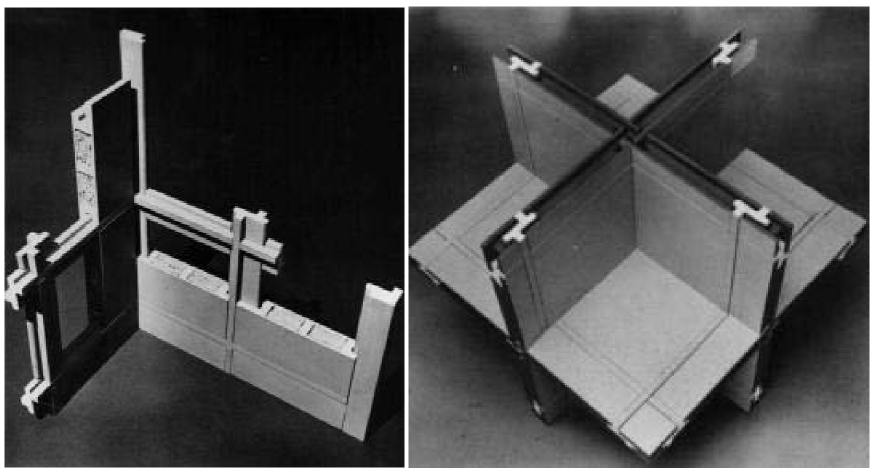

Image 10. Details of Wachsmann's Panels & Connectors for the Packaged House[59]

Image 11. The Packaged House by Konrad Wachsmann & Walter Gropius[60]

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[58] Colin Davies, *the Prefabricated Home.* (London: Reaktion Books, 2005), 23.

[59] "Packaged House by Konrad Wachsmann and Walter Gropius (1941-1952)," Housing.com, JPG file. <http://www.housing.com/sites/default/files/imagecache/mini_slideshow/packaged_house_general_panel_system_gropius_wachsmann_007.jpg> (accessed May 3, 2012).

Types of Panelized Wall Systems

Panelized wall systems, are a modular floor-to-ceiling wall system that defines space with a sense of permanence without being permanent, allowing for adaptability of existing spaces. Although traditionally used for office and commercial applications where versatile use of space is preferred for often temporary occupancy, moveable walls have the potential to be of use in the residential sector as well, primarily for rental units or first-time home buyers.

Haworth Design Studio and Design & Partners in Milan designed the Compose Open Plan system and Enclose Movable Wall system that allow for versatility in the office space. This versatility allows for the formation and integration of private offices to collaborative and open spaces. If taken to its basic functions, the same idea can be applied to affordable housing as well. According to an article on HGTVpro.com, the U.S. Department of Housing and Urban Development (HUD) has been exploring flexible home designs through their PATH program (Partnership for Advancing Technology in Housing). The program has determined through its research that consumers place a high value on the ability to reconfigure their floor plans with ease.[61] Additionally, panelized wall systems have the potential to allow for easier deconstruction or disassembly either by reusing the panel as a whole component, or easily removing the panel and deconstructing it on the ground into smaller reusable components.[62]

There are numerous types of prefabricated wall systems that function differently in the home. The following is a list of the most common wall panels available today for exterior and interior applications.

Exterior Wall Systems

Structural insulated panels (SIPs) are wall panels that provide load-bearing support for the building and are typically used in exterior wall applications as they also contain thermal insulation to slow down heat transfer between interior and exterior spaces. SIPs typically use sheets of wood or wood products (plywood or OSB) or sheet metal that sandwich some type of rigid foam insulation such as expanded polystyrene foam. Though not considered the most environmentally friendly type of insulation on the market, rigid foam insulation, when adhered to the plywood or OSB sheets, acts as a bridge and reduces buckling of the panel. Wood SIPs can also use pressed agrifiber outside as well and also have open-wall systems that are constructed similarly to traditional wood framing methods in which insulation can be blown-in on site. There are also precast concrete sandwiching systems on the market that use a double wall of precast

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[60] Ezra Stoller. *General Panel Corporation prefabricated home, exterior, façade, entrance side.* California, 1948.

[61] Stacy Hunt. "Moveable Walls Change Spaces." *HGTVpro.com*. (accessed September 27, 2010).

[62] Mark D. Webster and Daniel T. Costello. "Designing Structural Systems for Deconstruction: How to Extend a New Building's Useful Life and Prevent it from Going to Waste When the End Finally Comes," paper presented at GreenBuild Conference, Atlanta, GA, November 2005, 6.

concrete held together with steel trusses. Various types of insulation can be used with this system.[63]

Image 12. Structurally Insulated Panels (SIPs)[64]

Off-site assembled wall panels (or 'cassettes') are factory-assembled panels that contain insulation, vapor barrier, drywall lining, door and window frames, glass, wiring, and siding.[65] They involve a greater level of off-site fabrication and include more functioning parts than structurally insulated panels. The benefit of these types of wall panels is that they are a lot faster to assemble and on-site installation of piping and electrical wiring is kept to a minimum. Cassettes also applies to flooring systems that accommodate plumbing and often times radiant heating systems.

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[63] PATH study reviewed precast concrete sandwich system from Dukane Precast Inc. Photo provided in report indicated rigid foam insulation but the report did not further specify whether other types of insulation can be used with this system.

[64] Structural Insulated Panel Association. http://www.sips.org/wp-content/uploads/2011/04/Grand-Bear-89.jpg (Accessed 14 February 2012).

[65] Colin Davies, *The Prefabricated Home.* (London: Reaktion Books, 2002), 150.

Image 13. Off-site Assembled Wall Panel[66]

[66] "Bensonwood OSB Plus Wall." ArchitectureWeek.com. <http://www.architectureweek.com/products/images/2011.0126BensonwoodOBPlusWall.250.jpg> (accessed March 9, 2012).

Interior Wall Systems
Interior walls can be as simple as a partition wall, used solely for dividing space and providing privacy amongst rooms or it can serve functional means such as housing plumbing systems and electrical wiring. Traditional home construction methods usually encase utilities such as plumbing, electrical wiring, and data cables within walls, making any post-occupancy changes labor intensive, time consuming and costly.

Partition Walls
Partition walls are generally non-structural space-making devices used to divide large volumes into smaller, more intimate spaces. Although they are more typically used in office applications, other forms of partitions have been implemented in residential applications such as the forms of sliding screens, room dividers, and even fixed partition walls. Single-family homes constructed in Hawaii during the 1970's utilized combination of exterior double-wall construction and interior single-wall construction. The interior single-walls can theoretically be considered non-structural partition walls.

Visual and acoustic privacy are the two primary considerations that partition walls need to address. However, the level of desired privacy can be controlled by allowing for a variety of configurations within the panel. Thermal insulation is generally not needed for interior partition walls unless the partitions are used to separate spaces that need to be environmentally controlled.

Electrical walls & Flexibility
Floor molding panels in partitions are a common detail in commercial construction that allows for easy access to wiring. Wires are threaded at the base of the wall partition through a continuous channel that opens from the front.

Baseboard raceways function in a similar way for home applications. The raceway is attached on the outside of the wall and has a Snap-On cover and trim, allowing for easy access to electrical and data wires. The raceway is also designed to look like baseboard molding, making it an aesthetic and practical solution for residential use. The raceway was developed in response to the need to introduce and upgrade computer and telecommunication wires into the home.

Image 14. Example of Electrical Raceway in a Commercial Setting[67]

New technologies are also being developed that aid in designing for post-occupancy adaptability. A high-tech version of the electrical raceway is the Eubiq flexible electrical power outlet system by the Australian company Big Innovations. The system consists of either surface mounted or recessed power track into which adapters, lights, and other electrical connectors can connect to. The system also allows for the repositioning of power access points along the linear track which enables users to set up equipment almost anywhere along the linear track.

Image 15. Big Innovations' Eubiq Flexible Electrical Power Outlet System[68]

[67] "Power Base." Haworth.com. <http://www.haworth.com/_layouts/Haworth.ProductCatalog/Handlers/GetAsset.ashx?cid=239&rid=1994&type=Hero%20Shot> (accessed March 9, 2012).

Flat-wire technologies such as flat-wire tape, allows for post-occupancy change of electrical and telecommunication fixtures by applying itself to the face of the wall. Its flat profile can be painted over and easily camouflaged. [69] The drawbacks to this technology are that it is expensive and is stuck on with adhesive, requires camouflaging with compound and paint, and cannot be reused.

Image 16. Flat Electrical Wire[70]

Plumbing walls

Plumbing is one of the more difficult and complex issues when considering flexibility. Water damage is one of the most common causes of building deterioration and can result from a home's plumbing system, not only water infiltration from weather. Because of this, the most expensive spaces to construct are often kitchens and bathrooms.

As kitchen and bathrooms are the most technically complicated and expensive rooms in a dwelling, they are the best prospects for factory production because of their relative size, complexity and cost. In KieranTimberlake's Loblolly House (see page 96), the plumbing needed for the bath and kitchen units were addressed by using factory-built bath and kitchen units while the rest of the rooms were constructed using prefabricated panelized walls and floor components.

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[68] Big Innovations. "RH2 Track in Kitchen." <http://biq.net.au/newtest/wp-content/uploads/2011/11/RH2-in-kitchen-4.jpg> (accessed March 9, 2012).

[69] "Hide your wires in plain sight with FlatWire's Flat Wire." *eUpgrader.com.* http://eupgrader.com/635/living/hide-your-wires-in-plain-sight-with-flatwires-flat-wire/ (accessed December 8, 2010)

[70] "Speaker Wire." FlatWire.com <http://www.flatwireready.com/images/products_images/audio_products/FLT.jpg> (accessed March 9, 2012).

Another method of efficiency in plumbing is to design shared plumbing walls. This involves configuring bathrooms, kitchens, etc. so that plumbing fixtures share pipes in a single wall. Flexibility in designing the dwelling is for the most part preserved if these "wet functions" are located in neutral areas such as between fluctuating functional zones.[71]

Flexible PVC plumbing also allows for the extension of lines from the main hot- and cold-water pipes to any location on floors.[72]

Image 17. Flexible PVC Piping[73]

[71] Avi Friedman. *The Adaptable House: Designing Homes for Change.* (New York: McGraw-Hill, 2002), 125-126.
[72] Ibid, 144-145.
[73] FlexPVC. "Flexible PVC Piping." <http://flexpvc.com/pictures/flexpile2.jpg> (accessed March 9, 2012).

Pre-Cut Homes

Pre-cut homes are homes whose materials have all been pre-cut and then shipped to the construction site where they are assembled. These homes arrive in a kit of parts and include catalog home kits, log homes, and dome homes.

Image 18. Concept of Precut Home – Pre-Cut Sauna Kit[74]

Modular standardized building components have been used in housing construction for centuries and are to an extent considered the foundation of the prefabricated home. Masonry units, dimensional lumber, standard light gauge metal framing are all examples of standardized building components. A more recently introduced product is the timber-panel which are hollow timber blocks that slot together to form load-bearing timber walls. No glue or fixings are necessary with this system and the blocks are small and light enough to install without any machinery. Once constructed, the walls can then be filled with blow-in insulation to reduce thermal heat transfer.[75]

Image 19. Steko Blocks[76]

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[74] Pre-cut Sauna Kit. Steam and Sauna Connection. http://steamsaun.com/Graphics/pre-cu1.jpg (Accessed 14 February 2012).

[75] Cathy Strongman. *The Sustainable Home: The Essential Guide to Eco Building, Renovation and Decoration.* (London: Merrell, 2008), 14.

[76] Steko Holz-Bausysteme AG. http://www.steko.ch/fileadmin/ablage/bilder/gallerien/technik/001.jpg (Accessed 14 February 2012).

Building Code Information on Panelized Systems

With the exception of manufactured/mobile homes, prefabricated homes need to comply with regional, state, and local building codes for the site which the building will occupy. The City and County of Honolulu define "factory-built buildings" as any structure or portion of a structure that is designed primarily for occupancy by human beings which is either entirely prefabricated or assembled at a place other than the building site.

Factory-built buildings that are manufactured within the City and County of Honolulu are required to bear an insignia of approval that is issued by a City building official that indicates compliance with Article 3 of Chapter 16 of the Revised Ordinances of Honolulu. Factory-built buildings manufactured outside of Honolulu needs to bear an insignia of approval from an approved government official.

All electrical and plumbing work performed within the State must comply with State of Hawaii contracting and licensing laws and regulations. If this work is performed outside of Hawaii, the work must be done either by an electrician or plumber licensed in the jurisdiction where the factory is located or under the supervision of a licensed electrician or plumber if a quality control manual is provided by the manufacturer.

The preparation of plans and the observation of construction for factory-built buildings shall be by an architect or structural engineer licensed in the State of Hawaii. Plans and specifications need to be approved by the City and County of Honolulu prior to fabrication. Factory-produced buildings require periodic inspections during the manufacturing process to verify that the building complies with the approved plans. If the building is manufactured outside of the city, an approved third-party inspectional agency is needed to inspect the building.

Benefits of Prefabrication

Methods of prefabrication have the ability cut down construction costs since they can be constructed in controlled environments, make effective use of materials, and generally utilize cheaper labor. Modular and panelized home fabrication plants typically are able to hire inexperienced workers to build the components. Because these employees are considered assembly-line workers rather than skilled construction workers, manufacturing plants are able to hire these workers at a lower cost. Construction in the field is more expensive because it requires a higher amount of journeyman (skilled) labor in relationship to apprentice (less skilled) labor. Because journeymen are trained and considered highly skilled, their higher pay rate is reflective of their expertise. Building components that are preassembled in an off-site workshop is still less expensive because builders are able to use a higher ratio of apprentices to journeymen.

The standardization of components that stemmed from notions of factory production in housing are also believed to allow for a higher amount of quality control as components are assembled in an environmentally controlled space. Unlike on-site construction, prefabrication is less likely to be delayed or affected by rainy weather conditions.

Shortcomings in the Prefabrication Movement

In concept, the notion of prefabrication seems to be the perfect solution for creating affordable housing, yet it has never really achieved the success it promised. In his book, *the Prefabricated Home,* Colin Davies blames this on the 'problematic' relationship between architecture and prefabrication caused by their principles and prejudices. He also argues that many high-profile architect-designed prototypes for mass-produced housing were all failures from the standpoint of mass-production because they were one-off examples that could or would not appeal to the masses. 'You can't learn from them, except in the negative sense…how to make cheap, practical houses that ordinary people want to buy or rent.'[77] Davies argues that prefabrication has actually achieved success in the market, but in the realm of architecture, its success is not recognized within the realm of architecture. While Davies assumes heavy blame on the exclusionary tendencies of the architecture profession for this problematic relationship between architecture and the prefabricated home, another problem is in the very nature of the prefabricated home which Davies himself inadvertently points out:

> *The one-off house for a sympathetic patron does not provide an appropriate model for the relationship between designer and buyer of a prefabricated house…The customer is not an individual but a market sector and the house must have general appeal. For most market sectors, this means that it must speak the common language of domestic architecture that everybody will understand.*[78]

[77] Colin Davies, *the Prefabricated Home.* (London: Reaktion Books, 2005), 44.
[78] Colin Davies. *The Prefabricated Home.* (London: Reaktion Books, 2005), 202-203.

One of the key driving arguments in support of prefabrication in housing construction is that standardization of building components produces an efficient way of reducing construction costs by minimizing waste and the cost of labor. However, over-standardization leads to boring, unidentifiable buildings which for urban housing can be extremely detrimental. When residents are unable to identify with the space, they will find ways to make it their own and without any design influence, the results could be disastrous. Otherwise, they may also refuse to take responsibility for the care of areas outside of their home, which could lead to an unsafe neighborhood.

According to Sam Davis, the key to creating successful affordable housing is to find a balance between standardization, variation and resident identification. Variation allows residents to identify with their environments, encouraging desirable behaviors such as increased maintenance and care for the overall building and neighborhood surveillance.[79]

Another issue that both the flexible housing movement and designing for deconstruction movement have against prefabrication is the shift toward fully formed, inflexible products that cannot be disassembled or rearranged in a simple manner. According to Tatjana Schneider and Jeremy Till in their book, *Flexible Housing,* at the beginning of the prefabrication movement in housing, the notion of prefabrication and flexibility were often linked in the architect's mind. Both Le Corbusier and Walter Gropius expressed that standardization in production did not imply inflexible standardization of homes but was an opportunity to provide the greatest possible variability in floor plan using lightly constructed walls and partitions.[80]

The topic of prefabricated homes has also raised an issue with local construction companies and labor unions who complain that doing so takes away jobs for skilled labor trades. However, prefabricated panelized systems still need some amount of on-site assembly so utilizing such a system does not eliminate all work for local builders. Also, prefabrication does not need to occur on the mainland or abroad. In Hawaii, developers Castle and Cooke set up their own workshops where they prefabricate components that are project specific.

Another setback with the prefabrication movement is that the focus of experimentation and development that allows for flexibility and customization is limited to an extent to the production of single family homes. Even in Hawaii, customization of prefabricated homes or components for homes is seemingly reserved for the single-family housing market. Standardization is an important factor in reducing construction costs for multifamily urban housing as well, but in many Honolulu urban affordable housing projects, standardization is often taken to the extreme, resulting in buildings and dwelling units lacking character and resident identification.

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[79] Sam Davis, *the Architecture of Affordable Housing.* (Berkeley: University of California Press, 1995), 83-86.

[80] Tatjana Schneider and Jeremy Till. *Flexible Housing.* (Amsterdam: Elsevier, 2007), 21-22.

2.2 Adaptability & Flexibility

While the prefabrication and standardization of the prefabricated housing movement are highly economical, some level of variation also needs to be incorporated in the design of affordable housing in order to provide a sense of humanity and livability for its residents. Affordable housing architect, Sam Davis, mentions that providing options to affordable housing residents empowers them and instills a sense of pride in their homes. The feeling of being able to exercise some sort of control over ones' environment should not be overlooked because doing so could lead to vandalism and ultimately unsafe environments as demonstrated in the Pruitt-Igoe public housing project.[81]

Often times existing housing will not meet all of the needs of new residents especially when affordability is an issue. Many people will often just take the best they can get. Adaptable or flexible housing is a type of housing that allows for easier changes to spaces over time and gives the user a little more control over the function and layout of their home. Its construction and design principles can also address the carrying costs associated with affordable housing – primarily the cost of maintenance.

Various methods of flexible or adaptable housing have been explored and experimented with since the 1920s when experimentation in housing production was at its peak. Flexible housing and user participation has been heavily researched in Britain, but flexible housing design (particularly in multi-family housing) has yet to become mainstream practice in the U.S. For the most part, developers' responses to ever-changing housing demand have been to offer a variety of pre-set, fixed options such as a certain number of bedrooms and baths per unit, different flooring or cabinet finishes, etc.

Changing Needs in Housing

Buildings not only have an expected life span but they are also designed in such a way that addresses the needs of individuals (whether real or assumed) of a specific place and time. Avi Friedman gives a brief summary in his book *The Adaptable House* on the changing needs of households as a result of historic events or significant developments such as the introduction of reliable methods of birth control affecting the size of families, the general acceptance of inevitable change as a result of numerous technological advances, and an expanded definition of "family" that resulted from general acceptance of nonfamily unions, same-sex marriages, and increasing divorce rates.[82]

Not only has the concept of changing society affect housing but changing needs of individuals households continue to change as they go through life. Childless young couples may only need one bedroom at first but will need more when/if they decide to have children. Growing children require different spatial arrangements as they become young adults, desiring more privacy. Aging also causes physical and mental deterioration for many people and becomes of increasing

[81] Sam Davis, *The Architecture of Affordable Housing.* (Berkeley: University of California Press, 1995), 16.
[82] Avi Friedman. *The Adaptable House: Designing Homes for Change.* (New York: McGraw-Hill, 2002), 2-5.

concern when seniors remain in homes that do not address these needs. Unrelated people may want to double up on a unit in order to save money but they would ideally still like to maintain private quarters.

Materials, furniture, and color schemes are more easily changeable but functional spaces are often more difficult to change because of the fixed nature of traditional space-making elements like walls. It is nearly impossible for a unit to address the needs of every household that resides in it. Designing adaptable homes allow for more flexibility for residents to outfit their units as desired.

A Brief Background of Adaptability in Housing

Recognition of the ever-changing needs of the housing market has been explored in the past. Explorations in the adaptability of housing began during the extensive experimentation of housing development that occurred both in Europe and North America as a result of World War II[83] around the same time that prefabrication in housing was being explored. While North America has focused on adaptability in single-family homes, Europe has done more extensive studies and experiments with multi-family housing.

Single-family Adaptable Housing

In the 1940's and 1950's, both North America and Europe experienced significant increases in housing demand as a result of the two world wars. In North America, several coinciding factors led to what Avi Friedman calls an "exodus to the suburbs" including prosperity enabling families to purchase larger homes; large amounts of cheap and readily available land; government-sponsored homeownership programs that encouraged the preference for the single-family house; and increased means for mobility such as the evolution of automobile-oriented culture and the growth of highway and railway infrastructure.[84] At this time, the United States had a heavy political, economic, and social influence in Hawaii, and naturally its preferences and values in housing were reflected in the development of Oahu's urban fabric.

People invest much of their identity in their homes and single family dwellings often are representational of a person's self-worth, resulting in the American population viewing the single family detached dwelling as the symbol of achieving self-sufficiency and "the American dream." The 3-bedroom, two-bath single family home has become the norm for the traditional four-person nuclear family household (consisting of two married parents and two children). Also, the single family detached house is easier to monitor, protect, and adapt as families' needs change. [85]

However, this type of housing is an unsustainable form of housing from many different angles. As populations grow, this type of housing requires more and more land as well as the construction of more roadways and infrastructure to connect residents to job centers. As an

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[83] Avi Friedman, *The Adaptable House: Designing Homes for Change.* (New York: McGraw-Hill, 2002), 19.
[84] Avi Friedman, *The Adaptable House: Designing Homes for Change.* (New York: McGraw-Hill, 2002), 21.
[85] Sam Davis. *The Architecture of Affordable Housing.* (Berkeley: University of California Press, 1995), 8-9.

attempt to accommodate the desires of the typical American household (low-income households included) to own a single family, detached dwelling, many developers still opt to develop subdivisions.

Multifamily Flexible Housing

In contrast to North American suburban sprawl, European housing took a more vertical approach due to its deep rooted urban traditions. Because post-war Europe needed rapid rebuilding of its housing stock, governments became the main economic and regulatory engines for Europe's housing industry. Although they highly encouraged and supported innovative construction methods and technology, European governments also imposed numerous standards to control costs. These regulations consequently resulted in stark, monotonous high-density housing projects that occupants were unable to identify with.[86]

For most of history, affordable housing and public housing projects have typically been in the forms of apartments. As an economic solution to provide housing at high densities, apartments minimize the needs of roadway or infrastructure construction to support the number of housing units, require less land, and have the ability to provide community and social interaction for its inhabitants based on proximity (depending on the design and amenities provided). However, apartments (particularly high-rise apartments) can physically isolate its residents from the surrounding community which can be a crucial concern when dealing with low-income households.

Being able to control the initial design of your home as well as adapt it to suit your needs over time is an appealing aspect of a single family home that can be applied to urban multifamily housing. Significant strides in adaptable multi-unit housing occurred as a result of Dutch architect John Habraken's design methodology that separated occupant use from its physical structure.[87] Separating these two elements allows for more easily adaptable space. Structural members such as beams and columns remain fixed and permanent while non-load bearing walls are able to be reconfigured, removed, or replaced at will. Tatjana Schneider and Jeremy Till's studies on multi-family flexible housing design pointed out that the design "the Speculative Office" could be used as a model for the construction of flexible multifamily housing in the future[88] which takes advantage of flexible housing design construction methods and technologies such as separation of support and infill, layering of building systems, component legibility, and easy access to utilities.

User Participation in Flexible Housing Design

In the late 1960s, flexible housing design was studied and experimented with significantly in Europe as a response by architects and sociologists toward enabling user participation and

[86] Avi Friedman. *The Adaptable House: Designing Homes for Change.* (New York: McGraw-Hill, 2002), 32.
[87] Avi Friedman, *The Adaptable House: Designing Homes for Change.* (New York: McGraw-Hill, 2002), 33-34.
[88] Tatjana Schneider and Jeremy Till. *Flexible Housing.* (Amsterdam: Elsevier, 2007), 164-166.

empowerment.[89] This area of study has been particularly prevalent and heavily discussed in Europe where it was "seen as a 'democratisation' as well as 'decentralistion' of the planning process – particular in the public sector."[90] The underlying sentiment of flexible housing experimentation at this time was that "not to reckon with the originality and unique character of each person is to negate one dimension of Man."[91]

This sentiment was expressed by French architects Luc and Xavier Arsène-Henry who were among the leaders of the flexible housing movement in Europe at this time. The Arsène-Henrys defined three principles based on their belief of user participation in housing:

> *1. Everyone should be able to fit out his home was he wishes, including the right to make mistakes as part of that freedom...2. Each person ought to be able to express himself as a function of his choices. His home should be personalizable…3. Each person should be able, in his home, to make a creative act by organizing his space, based on the context within which he finds himself. Even being a co-author brings a measure of satisfaction.*[92]

User participation as the driving motivation behind flexible housing design means that to an extent, the architect gives up some semblance of control over the design of a project. In Lars Lerup's opinion, "the dweller brings so much of his or her own that, by comparison, the parts supplied by architects are the 'mere scaffold of habitation.'"[93] This "scaffold of habitation" refers to John Habraken's concept that the architect should provide only the simple structure and services of a housing project. Lerup clarifies that his own concept of "building the unfinished" does not mean that the building itself is unfinished but rather that it is "one component of the set, other components being the dweller's own props and doings (habits and actions). The physical comes alive through use."[94]

In addition to the design of the "scaffold" or "supports" of housing, the role of architects and designers could also involve creating "conditions and components necessary for choice."[95] According to Avi Friedman, this would involve the design of the structure, shell and openings, the placement of the main utility access to the shell, continue on to the development of alternative layout configurations or space modules by the builder (to be selected by the buyer), and could also include the design of subcomponents such as furniture, partitions, etc. The

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[89] Tatjana Schneider and Jeremy Till. *Flexible Housing.* (Amsterdam: Elsevier, 2007), 28.
[90] Tatjana Schneider and Jeremy Till. *Flexible Housing.* (Amsterdam: Elsevier, 2007), 28
[91] Luc and Xavier Arsene-Henry, quoted in Tatjana Schneider and Jeremy Till. *Flexible Housing.* (Amsterdam: Elsevier, 2007), 28.
[92] Luc and Xavier Arsene-Henry, quoted in Tatjana Schneider and Jeremy Till. *Flexible Housing.* (Amsterdam: Elsevier, 2007), 28-29.
[93] Lars Lerup, *Building the Unfinished: Architecture and Human Action.* (Beverly Hills: Sage Publications, 1977), 24.
[94] Ibid, 24.
[95] Avi Friedman, *The Adaptable House: Designing Homes for Change*. (New York: McGraw-Hill, 2002), 181.

designer could also act as facilitators in a choice process and help ensure that interior design decisions coincide with those of the exterior.[96]

Preoccupancy & Post-occupancy Adaptability

According to Avi Friedman, two concepts of adaptability have evolved as a result of the experimentation that occurred in the U.S. and European housing industries during the post-war era: preoccupancy and post-occupancy adaptability. Preoccupancy adaptability provides choices and means of adaptability prior to moving into the unit. Generally this is easier to do in custom-designed homes and single-family homes as the client is often known to the designer. The number of rooms, layout, and finishes can be decided by the intended owner. In tract housing, this is more difficult because the intended user's preferences are assumed. The most common form of preoccupancy adaptability in multi-family housing is the variation of unit size and layouts.[97] Involving occupant participation and input during the planning stages of the design process is also a method of providing preoccupancy adaptability.

Post-occupancy adaptability is the ability to adapt or modify a home after occupants have moved into the unit. Renovations, remodeling and additions are a few examples of post-occupancy adaptability and are generally more easily done on single family homes. Loft conversions, movable partition walls, and space-making devices are some examples and methods of post-occupancy adaptability used in multi-family housing.

Good flexible housing design provides opportunities for both pre-occupancy and post-occupancy flexibility. Most of the flexible urban multifamily housing examples presented in Schneider and Till's book primarily focus on one or the other.

Elements of Flexible Design

According to Schneider and Till, methods of designing for flexibility fall into two general categories – "soft" tactics (also referred to as indeterminate methods) and "hard" tactics (also referred to as determinate methods). The difference between the two is the amount of user control versus professional influence over the design of the dwelling. Soft tactics generally encourage greater user control over the dwelling's design while hard tactics, usually employed by architects as prescriptive models of living, tend to limit user control.[98]

Indeterminate or "Soft" Design Approach

Schneider and Till's notion of soft tactics involve the designing of undetermined space or multi-purpose rooms (in a sense) that allows the user to adapt the floor plan based on their needs. With this tactic, the user has ultimate control of the use of a space while the designer has limited influence. Examples of indeterminate methods include allowing excess space that can be filled in at a later time, providing 'raw' or unfinished space that residents can fill in or build out,

[96] Avi Friedman. *The Adaptable House: Designing Homes for Change.* (New York: McGraw-Hill, 2002),181.
[97] Avi Friedman. *The Adaptable House: Designing Homes for Change.* (New York: McGraw-Hill, 2002),13-14.
[98] Tatjana Schneider and Jeremy Till. *Flexible Housing*. (Amsterdam: Elsevier, 2007), 6-8.

or removing labels from rooms so residents ultimately determine the function of the room rather than the architect.[99]

Soft tactics or indeterminate spaces are related to Jonathan Chapman's emphasis on designing "space" or "openness" in consumer products or objects that allows consumers/users to "[enhance] the degree of self that may be invested into the discursive engagement between subject and object."[100] Chapman's discussion on object meaning and experience is discussed further in Section 2.3 Lifecycle Building because of its focus on object meaning as a waste management strategy. The soft tactics described by Schneider and Till are examples of how this "openness" can be translated from object design to housing design.

Usable Circulation

Circulation is an important consideration for flexible housing because no matter what, people need to be able to move. As Schneider and Till point out the tendency for architects of multifamily buildings is to minimize the amount of conventional circulation (corridors, hallways, etc.) probably as a means of spatial efficiency and maximizing profitable and usable spaces. Counter intuitively, the authors propose rethinking the minimization and function of circulation and instead thinking of how to expand these narrow corridors and hallways to include other uses such as communal spaces and storage. These ideas are applicable for both exterior circulation and interior circulation as well. For example, single loaded corridors could be extended in some areas to include sitting or waiting areas outdoors; or inside a unit, hallways could be widened to include additional storage for books or linens.[101]

Determinate or "Hard" Design Approach

The second approach which Schneider and Till term "hard" tactics involves using elements that help determine the use of predetermined spaces. These elements could include movable or foldable walls, sliding partitions, or space-making furniture. In this case, the designer ultimately has control over determining the use of space. Generally these tactics are employed where space is limited.

Combining Tactics

According to Schneider and Till, generally a combination of both "soft" and "hard" tactics will produced the most successful flexible housing projects than heavily relying on one or the other. However, architects tend to heavily rely on hard tactics because their profession is heavily based on determinist approaches toward design.[102]

[99] Tatjana Schneider and Jeremy Till, *Flexible Housing.* (Amsterdam: Elsevier, 2007), 135-137.
[100] Jonathan Chapman. *Emotionally Durable Design.* (London: Earthscan, 2005), p. 161.
[101] Tatjana Schneider and Jeremy Till. *Flexible Housing*. (Amsterdam: Elsevier, 2007), 148-151.
[102] Tatjana Schneider and Jeremy Till. *Flexible Housing*. (Amsterdam: Elsevier, 2007), 7-8.

Table 4. Summary of Design Tools for Flexible Housing[103]

METHOD	DESCRIPTION	EXAMPLE
Indeterminate Building	A building that can accommodate different uses within the same structural system.	Terraced House, C19 Industrial Warehouse Building
Raw Space	Spaces that are not fully formed and their eventual spatial form is a shared production of designer and user	Frame and generic space (frame is permanent, space is flexible)
Excess Space	Extra vertical or horizontal space to accommodate varied spatial division	Double height spaces
Slack Space	Space provided by the designer without indication of what it might be used for. It is area that is anticipatory of potential occupation but does	Flat roofs that can be built upon, courtyards that can be filled in, alcoves that can have furniture built into it, balconies that can be glazed in
Adding-on	Growth by expansion beyond the original frame (can be horizontal or vertical)	
Expanding Within	Growth contained within the original frame (typically applicable for multifamily/multi-story structures)	
Joining Together	Expansion by joining two adjacent dwellings or spaces together	Joining two one-bedroom apartments to form one three-bedroom apartment
Switch Rooms	Rooms provided by the designer that can be used by one of two apartments. When the resident of the larger apartment does not need the switch room, they can give it up to the other unit.	
Dividing Up	Division or separation of a larger space or dwelling into smaller spaces or separate dwellings.	
Rooms without Labels	The provision of unnamed rooms which are versatile in function. The idea is that labels inhibit flexibility in the initial design and during habitation.	
Usable Circulation	The provision of larger circulation space so that it may accommodate other uses	Larger communal social spaces in corridors; storage or extra
Sliding and Folding Elements	Division/combination of space by means of sliding and folding partitions	

[103] Described by Tatjana Schneider and Jeremy Till in *Flexible Housing*. (Amsterdam: Elsevier, 2007), 131-160, 181-200.

Moving Wall	Provision of a plan that works with or without movable elements; usually moving walls that physically separate space are also acoustically sound unlike sliding/folding partitions
House as Furniture	Treatment of the house as a piece of complex equipment and design it in the most efficient manner possible
Room as Furniture	Treatment of individual rooms as pieces of furniture of build in furniture that folds out or down

Construction Methods & Technology

While Schneider and Till tended to polarize construction methods and technology into hard and soft categories, this report will refrain from doing so since it is meant to be more of a tool box of ideas rather than a categorization exercise. Furthermore, a bias is implied with categorization as Schneider and Till employed (whether intentional or not) which this report wishes to avoid.

Learning from the Speculative Office

The recommended approach to construction methods for flexible multifamily housing is often likened to that of the speculative office building. The speculative office building (like flexible housing) is designed with the anticipation of inevitable changing demands throughout the building's lifetime. In the speculative office building and multifamily housing, the end user is more or less unknown during the time of design. Therefore, it is a feasible consideration to learn from the construction methods of the speculative office building to inform those of flexible multifamily housing as well.

Support & Infill

The concept of support and infill is one that stems from the Modernist movement. Simply put, support primarily refers to the building's structure but can also include commonly permanent or fixed elements such as access, services, and the building skin (although this depends on the intent of these elements). The frame is generally the most flexible structural support system because it allows for long spans and non-load bearing internal partitions. One can utilize a generic frame with which design approaches such as Schneider and Till's 'bottle rack principle' can be used, or one can use a column and slab frame (similar to Le Corbusier's Maison Dom-ino project). This system places columns at the edges of the concrete slab, enabling openings to be positioned independently from the structural system.[104] Infill refers to the nonpermanent components of flexible housing such as internal partitions that are capable of being erected by an unskilled laborer.

[104] Tatjana Schneider and Jeremy Till. *Flexible Housing*. (Amsterdam: Elsevier, 2007), 166-168.

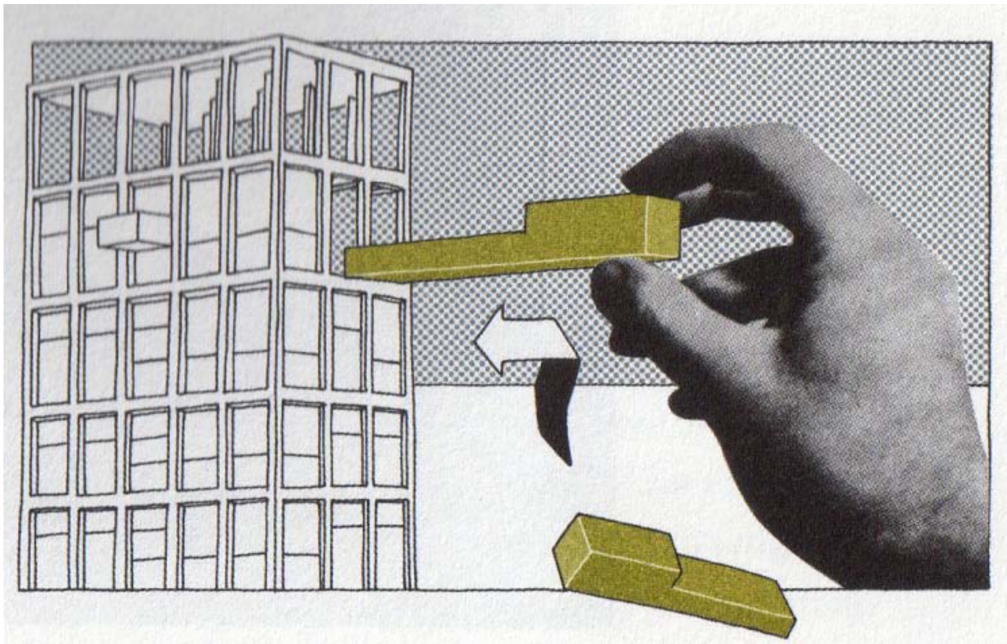

Image 20. Schneider & Till's Bottle Rack Principle[105]

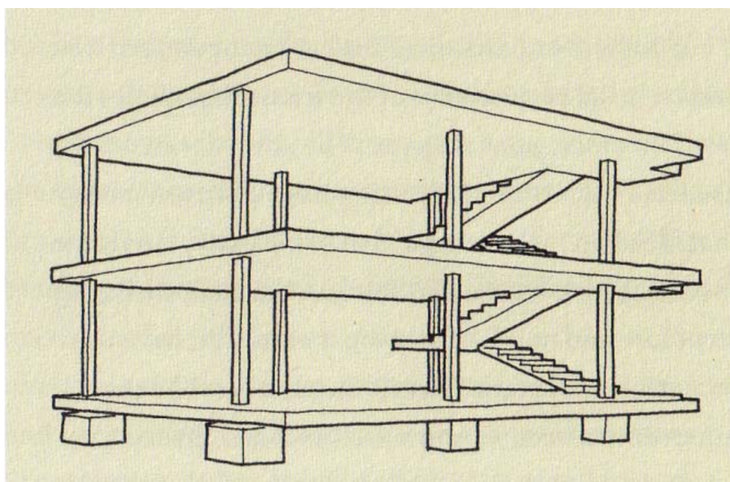

Image 21. Le Corbusier's House as Supporting Frame[106]

[105] Tatjana Schneider and Jeremy Till. "Figure 6.8: Bottle rack principle derived from Le Corbusier." *Flexible Housing*. (Amsterdam: Elsevier, 2007), 168.
[106] Tatjana Schneider and Jeremy Till. "Maison Dom-ino, Le Corbusier, 1914." *Flexible Housing*. (Amsterdam: Elsevier, 2007), 166.

Layering

In the speculative office building, building systems are generally layered to provide an ease of disassembly when tenants change and modifications need to take place. One is able to easily distinguish between the frame, cladding, partitions, services and finishes – all which are legible, separable, and have a determined life span that is accounted for. Each layer needs to be able to be modified, removed, or taken apart without disturbing any of the other layers.

According to Stewart Brand in his book *How Buildings Learn,* the idea of layering building systems originally stems from Francis Duffy, cofounder of the British design firm DEGW who distinguished four layers of a commercial building (Shell, Services, Scenery and Set) and determined that each layer had an expected lifespan different from the others. Brand expanded Duffy's four layers into six layers and revised the definitions of each layer to be applicable to other building types besides commercial ones, which is summarized in the table below.

Table 5. Stewart Brand's Definitions of Shearing Layers of Change[107]

LAYER	DEFINITION	USABLE LIFESPAN
Site	The geographical setting, urban location and legally defined lot	Eternal
Structure	Foundation & load-bearing elements	30-300 years (however, few buildings make it past 60 years)
Skin	Exterior surfaces	20 years
Services	Communications wiring, electrical wiring, plumbing, sprinkler system, HVAC, and moving parts (e.g. escalators and elevators)	7-15 years
Space Plan	Interior layout – the location of walls, ceilings, floors and doors	3-30 years (depends on use: commercial can last 3 years while homes may last 30 years)
Stuff	Furniture, appliances, tenant-owned objects	Daily

[107] Stewart Brand. *How Buildings Learn.* (New York: Penguin Group, 1994), 13.

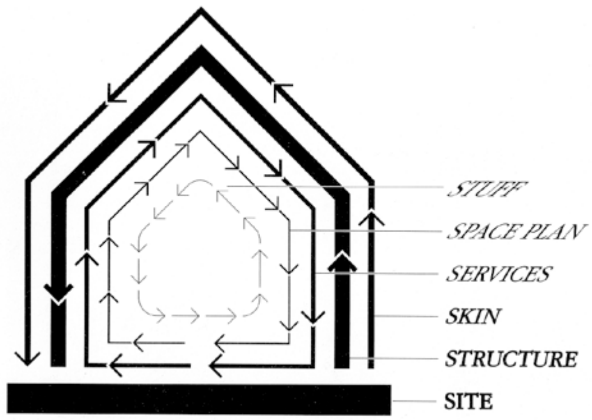

Image 22. Diagram of Stewart Brand's Shearing Layers of Change[108]

Duffy and Brand's notion of layering building systems has been referenced by advocates for flexible housing design and designing for deconstruction since both movements involve the aspect of time and lifecycle of a building. The consensus implies that these layers are best kept separate so that replacement of layers with shorter usable life spans (be it physical or technologically) would be easier to achieve, essentially prolonging the useful life of the building.

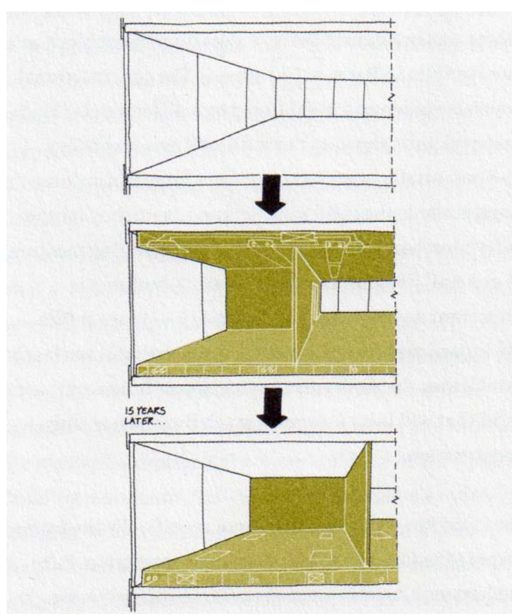

Image 23. Concept of Systems Layering Within the Speculative Office Building[109]

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[108] Stewart Brand. *How Buildings Learn: What happens after they're built.* (New York: Penguin Group, 1994), 13.

[109] Tatjana Schneider and Jeremy Till. "Figure 6.3," *Flexible Housing*. (Amsterdam: Elsevier, 2007), 165.

Legibility

Legibility – or the ability to easily see and understand how a building or component is put together – is maybe one of the underestimated concepts in the design of flexible housing. It is also an important concept in designing for deconstruction as well. Flexible housing does not necessarily imply that users should do the work themselves but should be able to (1) visually recognize that they are able to modify their dwellings and (2) understand how to do so. If users are unable to recognize this, it is less likely that the dwelling will be modified since users will be unaware that they are able to do so.

Schneider and Till note that the reason many flexible housing schemes have not fulfilled their potential is that later users and managers were not aware of the flexible features that were incorporated into their home or building.[110]

The desire for monolithic-like and/or integrated building systems is one of the major roadblocks that stand in the way of building legibility. Many prefabricated products – including panelized wall systems – bind the layers of construction together, fusing together structure, skin, insulation and inner finish layers (e.g. structurally insulated panels).[111] This limits the legibility of the construction of these elements, especially if services are included in the panel, which is sometimes the case.

Legibility is also encouraged in designing for deconstruction as well. Webster and Costello note that challenges in deconstruction and dismantling tend to occur with more complex and integrated building systems. Buildings with hidden building systems or components require more consideration to deconstruct because the true nature of the building and its systems is unknown. For example, it is impossible to see how concrete structural members are reinforced from the outside, lacking information such as strength and serviceability necessary to structural engineers to be able to reuse the member.

When designing building systems using DfD principles, generally, easily identifiable systems that are layered (rather than integrated) are preferred for ease of disassembly. Labeling structural members with material grade, species (for wood), or other information can help with identifying reusable material and determining its new purpose. Separation of structural systems from electrical, plumbing and mechanical systems better ensure their components' reusability. For example, if electrical wiring and plumbing are threaded through wood framing, this makes deconstruction more difficult and reduces the reuse value of the framing member.[112]

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[110] Tatjana Schneider and Jeremy Till. *Flexible Housing*. (Amsterdam: Elsevier, 2007), 200.

[111] Tatjana Schneider and Jeremy Till. *Flexible Housing*. (Amsterdam: Elsevier, 2007), 176.

[112] Mark D. Webster and Daniel T. Costello. "Designing Structural Systems for Deconstruction: How to Extend a New Building's Useful Life and Prevent it from Going to Waste When the End Finally Comes." (paper presented at GreenBuild Conference, Atlanta, GA, November 2005) http://www.lifecyclebuilding.org/files/Designing%20Structural%20Systems%20for%20Deconstruction.pdf (accessed April 25, 2011)

For these purposes, legibility plays a fairly crucial factor in providing information on how to adapt one's dwelling to accommodate changing needs, enabling user participation.

Modularity

Modularity in theory works because it implies interchangeability. However, according to Schneider and Till, it is generally easier to work with standardized systems rather than specialized modular systems which is what most modular systems in flexible housing utilize. Specialized systems developed by architects and product designers often do not consider the long-term sustainability of such a system. If the system becomes obsolete, it becomes difficult and expensive to find replacement components as often times it needs to be manufactured by a specialized contractor.

With modular design, it is logical for one to consider key dimensions taken from sources that hold influence of design or construction constraints such as standard building material sizes (e.g. 48" x 96" plywood boards) or accessibility requirements (e.g. 30" x 48" clear floor space; 60" turnaround space). Unfortunately, all of these limitations have all been developed under different circumstances with emphasis on different outcomes so there is little overlap or correlation between all of these "standard" dimensions.

A good example of a modular system that utilizes standard material sizes is Honor Oak Park designed by Walter Segal, Jon Broome and several self-builders. As Schneider and Till note, the key flexible element in the buildings is the lightweight dry, demountable wall system that utilizes standard panel sizes. Because the self-builders of this project were involved in the design and construction process, and also because of the easily accessible building materials, these residents have easily made adaptations and extensions to their homes[113] – a good example of flexible housing that lives up to its flexible potential.

Image 24. Honor Oak Park by Walter Segal, Jon Broome & Self Builders[114]

[113] Tatjana Schneider and Jeremy Till. *Flexible Housing*. (Amsterdam: Elsevier, 2007), 101.
[114] Emily Noden. "Honor Oak Park."
http://www.afewthoughts.co.uk/flexiblehousing/admin/images/81/1.jpg (Accessed 18 January 2012).

Prefabrication

Prefabrication in both housing and housing components has almost always been linked to flexible housing design to an extent because of its ability to mass-produce uniform quality components cost-effectively. However, as Schneider and Till point out, prefabrication does not necessarily infer flexibility. This is because many prefabricated elements are comprised of permanently fused components. For example, in the case of Structurally Insulated Panels (SIPs), the structure, insulation, exterior sheathing and interior layer is permanently fused together. If one chooses to use prefabricated components rather than panels (or perhaps panels that can be disassembled into further components), then more flexibility is allowed. Some of the best examples of prefabrication methods with flexibility are those which incorporate principles of simplicity and disassembly.[115]

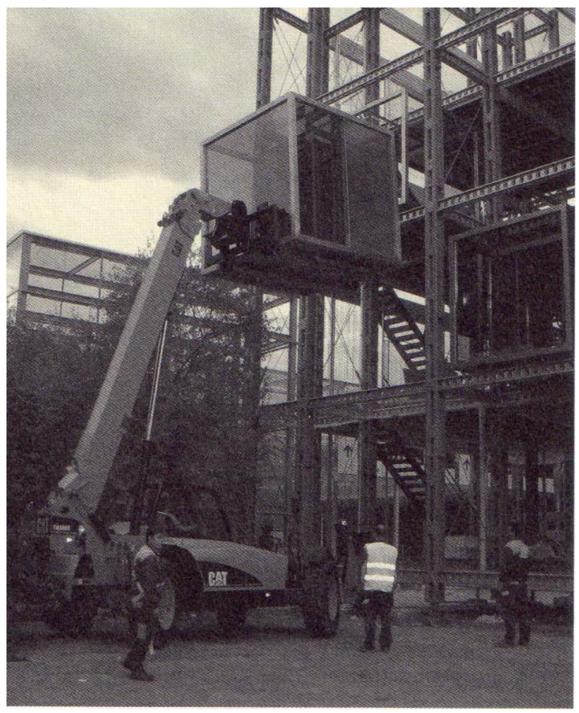

Image 25. Prefabricated Modules in Flexible Housing - Domino.21[116]

Movable Components

Movable components include movable walls and wall systems, sliding screen, curtains, space-making furniture, and fold-out furniture. There is a plethora of products and systems available that can be used as means of flexibility in buildings.

Space saving furniture such as fold-out furniture is another type of movable component in flexible design. Le Corbusier used built-in beds that folded up into walls. Once again referencing the flexible approach of the speculative office building – in conjunction with indeterminate

[115] Tatjana Schneider and Jeremy Till. *Flexible Housing*. (Amsterdam: Elsevier, 2007), 176.
[116] Tatjana Schneider and Jeremy Till. "Domino.21." *Flexible Housing*. (Amsterdam: Elsevier, 2007), 126.

design methods such as open plans, flexible and easily accessible utilities, many contract furniture companies (e.g. Haworth, Steelcase, Knoll, and KI) have developed movable wall systems that are used to create more spatial definition within the open office environment. These systems are modular, customizable (in terms of finishes), acoustically sound, and accommodate technological demands such as wiring for computers through the use of raceways and/or conduits.[117]

Image 26. Resource Furniture's Space Saving Furniture[118]

Schneider and Till point out however, that such wall systems often overlook the long-term considerations of sustainability by using specialized or complex technologies and unconventional module dimensions that limit the practicality of such a system. If a system is discontinued, replacement parts will no longer be available or will need to be manufactured by specialist contractors. Furthermore, some movable partitions may be so technically complicated that specialized contractors are necessary to move them as intended.[119] Complications such as these discourage users from adapting these walls as intended.

As Schneider and Till state, architects of flexible housing are generally more interested in movable components or what Schneider and Till call "hard" building technology. This is mostly because "there is a direct, almost simplistic, conviction that flexibility in architecture is best delivered through actual physical change."[120] While movable components are helpful tools, architects should not rely heavily (or solely) on such components to achieve flexibility in housing. Instead, they should be used as a means to an end in order to maximize flexibility.

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[117] "Dirtt Face-mounted Tiles." Dirtt Environmental Solutions. http://www.dirtt.net/public/products/_docs/brochures/FaceMountedTiles_brochure_lq.pdf [accessed 26 April 2011]

[118] Resource Furniture. www.resourcefurniture.com/space-savers (accessed April 27, 2011).

[119] Tatjana Schneider and Jeremy Till. *Flexible Housing*. (Amsterdam: Elsevier, 2007), 175.

[120] Ibid, 151.

Access to Utilities

Dealing with utilities such as plumbing and electricity can be daunting for the typical homeowner and non-expert. Conventional housing construction methods are often fixed and concealed, making it difficult for the dweller to make any changes without disturbing some part of the wall or floor or ceiling. Pipes, cables, wires, and other utilities are installed before the inner layer of a wall is installed, enclosing them within the wall. As Friedman notes, legible and separable access to these utilities (such as the use of raceways) further enable the occupant to adapt one's living space to his or her needs.[121]

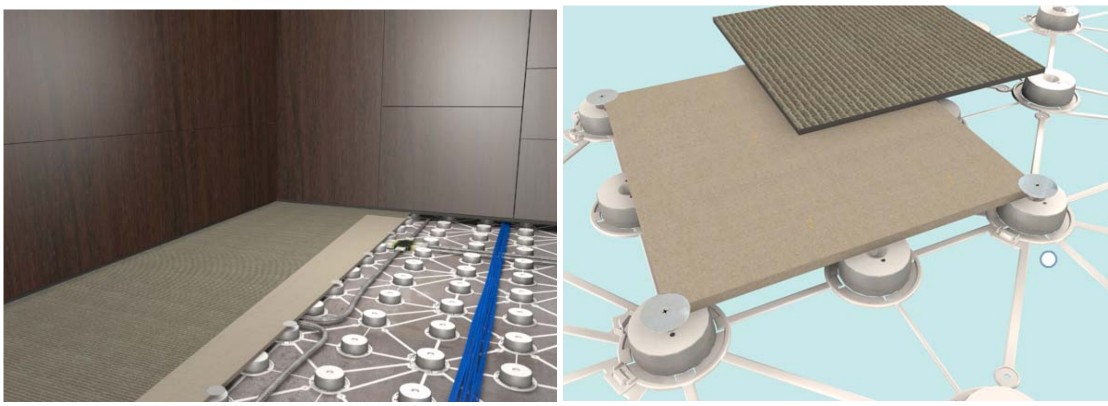

Image 27. Dirtt Environmental Solutions[122]

As mentioned above, movable wall systems used in commercial and office buildings sometimes include raceways for easy access to electrical and data cables. Some contract furniture companies that make these walls (such as Dirtt and Haworth) also have developed modular, raised floor systems that allow for easy access and flexible configuration of wires and cables. Most of these systems generally accommodate electrical and data distribution primarily because these generally take up less space, allowing for a lower ceiling. However, Haworth also has a raised floor system that can accommodate ventilation ducts beneath the floor (used in conjunction with a ceiling return system)[123] but at the expense of a higher profile.

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[121] Avi Friedman. *The Adaptable House: Designing Homes for Change.* (New York: McGraw-Hill, 2002), 169.

[122] Dirrt. www.dirtt.net (accessed April 25, 2011).

[123] "Underfloor Air." Haworth Inc. http://www.haworth.com/en-us/Products/Architectural/Access-Flooring/Pages/UnderfloorAir.aspx (Accessed 26 April 2011).

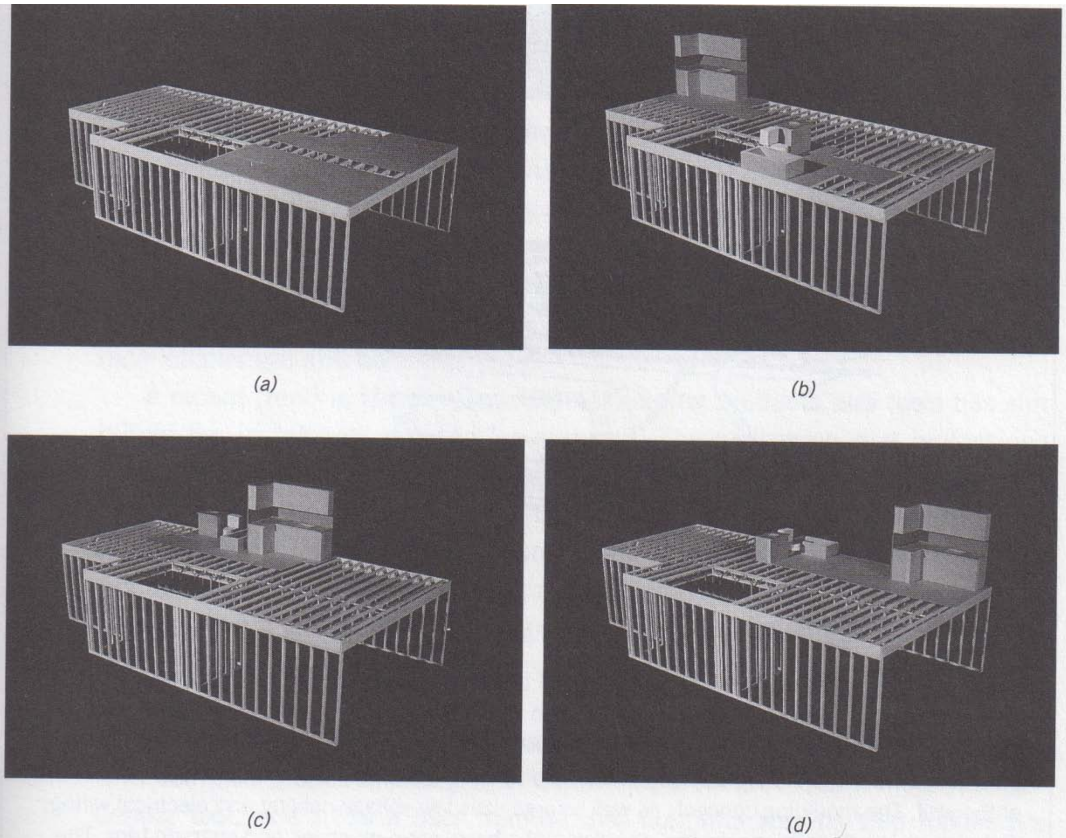
Image 28. Haworth's Underfloor Air System[124]

These raised floor systems used in the commercial office building is similar to Avi Friedman's concept of a chase which he describes as a passageway through which utilities can branch to different rooms in a house from a single known location.[125] The difference is that chases concentrate the location and access of utilities to one location while raised floor systems mentioned above generally allow for unlimited flexibility in terms of locating piping, ductwork, etc. Chases are ideally located along the perimeter of the house, or centrally in a hallway or corridor. They can be located beneath floors, in ceilings, or in walls. This provides convenient access to utilities by concentrating them in one location, ultimately increasing design flexibility.[126]

[124] Haworth. <www.haworth.com> (accessed April 26, 2011).

[125] Avi Friedman. *The Adaptable House: Designing Homes for Change.* (New York: McGraw-Hill, 2002), 170-171

[126] Avi Friedman, *The Adaptable House: Designing Homes for Change.* (New York: McGraw-Hill, 2002), 171.



A floor chase in an open-web floor joist system (*a*) and alternative locations of wet functions on a floor [(*b*) through (*d*)].

Image 29. Friedman's Notion of Floor Chase[127]

[127] Avi Friedman, *The Adaptable House: Designing Homes for Change.* (New York: McGraw-Hill, 2002), 171

Zoning is another method of providing convenient access to utilities. Concentrating all of the wiring and plumbing in one location generally allows for easy access at a singular entry point. Furthermore, the consolidation of similar functions requiring utilities (such as wet locations – bathrooms and kitchens) allow the utility lines to be located in one area, theoretically allowing for a more efficient and cost-effective use of space. In Cala Domus, designed by PCKO, a 'Living Wall' or service wall concept is utilized where a zone of space is designated for vertical and horizontal distribution of services such as electrical wiring, plumbing, and storage spaces for trash and recycling.[128]

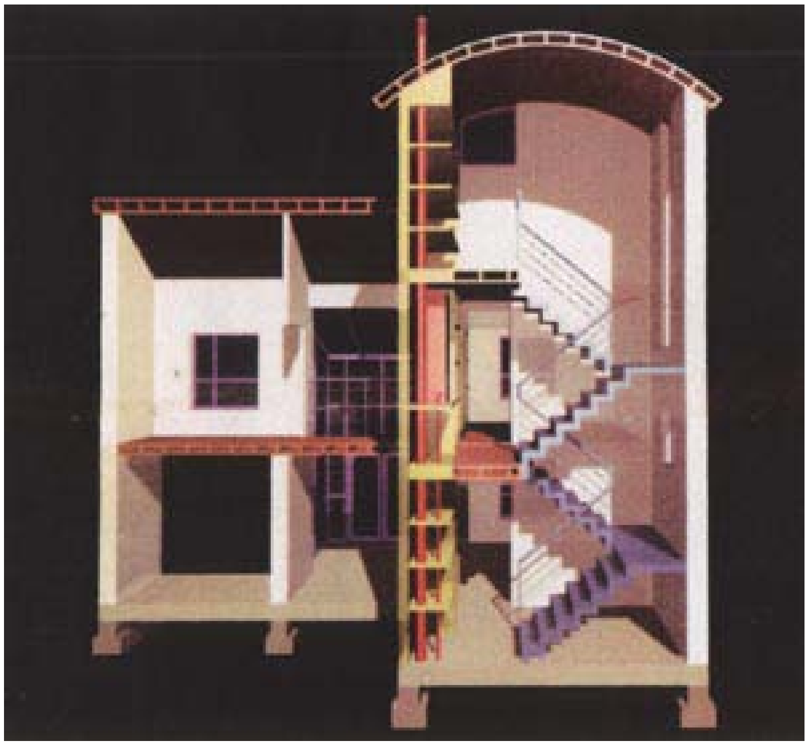


Image 30. Cala Domus by PCKO[129]

[128] Tatjana Schneider and Jeremy Till. *Flexible Housing*. (Amsterdam: Elsevier, 2007), 127.
[129]Flexible Housing. "Plan 2" *Cala Domus | PCKO.* <http://www.afewthoughts.co.uk/flexiblehousing/house.php?house=129&number=&total=&action=&data=&order=&dir=&message=&messagead=&photo=5> (Accessed 18 January 2012).

Shortcomings in the Flexible Housing Movement

Probably the most significant setback of the flexible housing movement is the almost guaranteed extra costs associated with the methods of flexible housing described above. Although Schneider and Till liken the long-term benefits of flexible housing design to that of sustainable and green building design, they acknowledge that there is a lack of quantitative data that would justify the higher initial costs to create flexible housing to developers.[130] Schneider and Till conducted an analysis on a series of flexible housing case studies, evaluating the various design tools used based on Cost, Cost Benefit, and Priority. Not all of the methods listed in the book were evaluated, but the ones that were involved at *least* a 2-5% increase in price when compared to conventional methods.[131]

Like the prefabrication movement, another major setback of the flexible housing movement is the focus of 'one-off' experimentation which limited the design appeal to the general public. This setback took form in the fixation of many architects on the technical solutions and movable elements rather than a flexible use of space.[132] The 'one-off' architecturally designed solutions for housing limited the feasibility of many of these projects (or rather the flexible components of the projects) to appeal to the masses. Many of these customized components were not interchangeable amongst other systems which was also limiting to the movement. Furthermore, as pointed out by Friedman, 'technical complexity deterred occupants from maximizing the full potential of such components.'[133]

Another setback is that user participation in housing generally occurs during the prior to construction or what Friedman terms 'preoccupancy flexibility.' It is the view of this paper that while preoccupancy flexibility is important, alone, it is shortsighted and that allowing for post-occupancy flexibility is ideal to allow for longer usefulness of a home.

[130] Tatjana Schneider and Jeremy Till. *Flexible Housing*. (Amsterdam: Elsevier, 2007), 43-44.
[131] Tatjana Schneider and Jeremy Till. *Flexible Housing*. (Amsterdam: Elsevier, 2007), 183-200.
[132] Tatjana Schneider and Jeremy Till. *Flexible Housing*. (Amsterdam: Elsevier, 2007), 7.
[133] Avi Friedman, *The Adaptable House: Designing Homes for Change.* (New York: McGraw-Hill, 2002), 47.

2.3 Lifecycle Building

Prefabrication and Flexible Housing emerged during times of crisis and as a necessary solution to address the public needs of their times. The Sustainability or 'Green Building' movement emerged in response to growing concern of the impact of the built environment at the expense of the natural environment. This growing concern has become the catalyst for housing experimentation today and has prompted a movement called 'Lifecycle Building' which is a design movement intended to factor the consideration of waste management strategies into the architectural equation.

Honolulu has recognized that it has the potential to be an exemplary model of a sustainable and environmentally-friendly metropolitan city particularly based on the state's climate alone. Photovoltaic systems are installed all over the state. State law requires solar water heating on any new residential project. Passive cooling strategies for residences are encouraged throughout the entire state. While these are all very necessary and important strategies for Hawaii, the State has missed the mark on a key element in sustainability – waste management. The environmental consequences of human consumption have been staggering – pollution, deforestation, destruction of natural eco systems, etc. Considering that Hawaii relies heavily on imported goods and materials, we are slowly on our way to becoming constipated. On the surface, it seems like Hawaii has been doing a good job of handling its waste – setting up a statewide curbside recycling and green waste program and converting a lot of its solid waste into energy through incineration. But a closer look reveals that Hawaii's current approaches toward waste management are not necessarily environmentally responsible actions and may also perpetuate its high cost of living.

Environmental & Economic Impacts of Materials

A considerable increase in environmental awareness since the 1970s has led to "sustainable" and "green" design becoming global buzzwords whose application has spanned across numerous disciplines and industries. The focus of green building has predominantly centered on energy efficiency and indoor air quality. While sustainable practices have been employed in the building materials market, it has been focused mainly around sustainably harvested or recycled materials.[134] Although many efforts have been developed to make buildings energy efficient, addressing the need to reduce embodied energy in buildings materials has not generated much attention until recently. Still, many design professionals believe that reuse and recycling are very important options for sustainable and environmentally-friendly design. In addition to diverting construction waste from landfills and conserving raw material resources, using reused and recycled building materials reduces the amount of energy used to ship raw materials to manufacturing plants, manufacture these materials into new products, and transport these products to building sites.

For Hawaii, this is especially important because we are so reliant on imported products. This reliance results in shipping and handling charges for merchandise or mark-ups in products sold by local distributers to compensate for these charges. Hawaii's construction industry is no different and has been highly reliant on importing its building materials from outside of the State of Hawaii. The cost of shipping and transporting materials drives up the cost of the material, which in turn drives up the cost of construction, and is ultimately reflected in the price of the building. In the case of housing, these prices are passed onto its occupants – renters and homeowners alike. It makes economic sense for Hawaii to become more self-sufficient. State and local governments have recognized the economic and environmental benefits of developing Hawaii's self-sufficiency and have been making strides toward becoming more independent as demonstrated by the increased attention on renewable energies and environmentally sustainable practices within the last few decades.

From an environmental standpoint, reducing and restricting the amount of landfills in Hawaii is especially important since land is a scarce and expensive commodity. The construction industry also generates high amounts and large pieces of debris during demolition, occupying a significant amount of space in landfills. Many building products also contain toxic chemicals, used to preserve materials, which are hazardous to both the environment and human health.

As Hawaii's population continues to grow and its cities continue to increase in density, many older homes are either demolished to make way for larger, more relevant homes, or renovated to adapt to new housing demands. Limited land resources necessitates constant and various forms of reconstruction for Honolulu's housing supply while also restricting the number and

[134] Public Architecture. *Design for Reuse Primer.* <http://designforreuse.org/design_for_reuse/DesignForReusePrimer.pdf > (accessed November 9, 2010).

sizes of landfills needed for general solid waste disposal. In 1999, approximately 30% of material sent to Hawaii's landfills was construction and demolition debris.[135]

This project's original hypothesis of reducing the cost of materials through building and material recycling ultimately fell short when research (through literature and personal interviews) revealed that Hawaii's current waste management strategies (as well as the way building products are currently designed) would not support a building and material recycling industry in its current state. Increasing awareness over the environment in general is likely to resist Hawaii's potential for a local recycling industry since recycling (though good in theory) is often thought of as similarly destructive as conventional manufacturing. However, the potential for a re-use market instead is much more feasible as a method to address the problem of limited local building material resources.

Part of the problem is that the fact that 'green building' ideas have been somewhat exploited to be used as marketing and advertising tools for products and companies. As a result, it's beginning to become more difficult to determine which products and approaches are actually 'good' for the environment and which are only claiming to be.

Hawaii's Construction Waste Management Resources

There are several types of construction debris waste management facilities located throughout Hawaii.

Landfills

There is only one landfill that is exclusive to construction-related debris which is in Nanakuli, Oahu. This 600-acre landfill is a privately owned by PVT Land Co. who says that the landfill has capacity until 2024.[136] There are other municipal solid waste landfills such as those at Waimanalo Gulch Landfill but mandatory recycling laws ban disposal of certain items such as scrap metal, large household appliances, and tires from City & County of Honolulu landfills.

Incineration (H-Power)

Incineration of municipal solid waste into refuse derived fuel (RDF) is another waste management strategy. Hawaii's incineration plant, operated by Covanta Honolulu, is referred to as H-Power and has been in commercial operation since 1990. The plant is located in Kapolei and processes about 2,160 tons of municipal solid waste per day, generating about 57 megawatts, which it sells to the Hawaiian Electric Company.[137]

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[135] Hawaii Advanced Building Technologies Training Program (HABiT). *Guide to Resource Efficient Building in Hawaii.* First Edition. January 1999. II-12

[136] Dan Nakaso, "Building debris raises concern." *Honolulu Advertiser.* April 18, 2004.

[137] Covanta Energy. "Covanta Honolulu Resource Recovery Venture". http://www.covantaenergy.com/covanta-us-home/facilities/facility-by-location/honolulu.aspx (accessed 20 November 2011)

Although perceived as healthier than landfills because it produces energy, incineration can release dioxins and other toxins during burning, particularly because combustible waste such as paper and plastic were never designed to be safely burned.[138]

Waste Sorting Services

The scrap metal ban from City & County of Honolulu landfills in 1994 generated the need for sorting out scrap metal for recycling from demolition debris. Although the ban only pertained to City landfills, some companies such as Island Demo Inc. have employees sift through construction debris to sort out building materials for recycling even if it is going to private landfills. Primarily metal is pulled from the debris for recycling into new structural members, while concrete, wood and glass typically end up in landfills.[139] However, even though these sorting services remove metal for recycling, the actual process for recycling is sent to mainland plants for remanufacturing.

The State of Hawaii Department of Business, Economic Development, and Tourism's Clean Hawaii Center has published several reports on managing construction waste both during demolition/renovation projects and during construction. There are some companies in Hawaii that try to recycle wood, concrete and glass into new and usable products.

Deconstruction contractors

While demolition of a building clears a building from a site, little care is taken to salvage or preserve any of its components for re-use since its ultimate destination is a landfill. Deconstruction, on the other hand, is the dismantling of a building with intentions of re-use, recycling, and waste management purposes. Re-Use Hawaii is a non-profit deconstruction contractor that deconstructs homes in Hawaii (primarily) and salvages the materials for resale to contractors, homeowners, artists and woodworkers. Homeowners who deconstruct their homes have to pay a deconstruction fee (usually ranging from $7,500-$13,000 depending on the home) but will also get a tax credit for donating their deconstructed home's materials to Re-Use Hawaii. According to co-founder Selina Tarantino, the deconstruction fee is comparable to typical demolition fees.[140]

Re-use Warehouses

Re-use warehouses are retail stores that sell salvaged and surplus building materials. Re-use Hawaii has its own re-use warehouse which sells material the company salvages from the homes and buildings it deconstructs. Other warehouses such as the Habitat for Humanity ReStores sells reusable and surplus building materials to the public at 25-75% of the retail price. Hawaii has five ReStores on four of its islands: Eleele, Kauai; Hilo and Kailua-Kona, Hawaii; Kapolei, Oahu;

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[138] William McDonough and Michael Braungart. *Cradle to Cradle.* (New York: North Point Press, 2005), 55.
[139] Dan Nakaso. "Building debris raises concern," *Honolulu Advertiser.* April 18, 2004.
[140] Sheila Sarhangi. "Razing houses, raising houses." *Hana Hou! The Magazine of Hawaiian Airlines.* October/November 2010, 70-77.

and Wailuku, Maui.[141] The stock for re-use warehouses are usually generated in the form of donations from either homeowners or contractors.

Recycled Materials

Sometimes, despite careful planning and disassembly, some materials are just not salvageable. However, there are several types of materials that have high potentials for recycling and should be separated during demolition for ease of recycling. These materials include concrete, asphalt, drywall, ferrous and non-ferrous metals, wood, building components and specialty items.[142]

Unfortunately, there have been little efforts of significance done to provide incentives for construction and demolition materials recycling statewide.[143] Each county is responsible for managing their own solid waste management programs, including construction and demolition waste management programs.

The City and County of Honolulu has produced several manuals and guidelines for construction waste management in compliance with federal government requirement. The table below lists recyclers in Hawaii that recycle construction and demolition materials or produce materials with recycling content used in the construction industry.

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[141] Habitat for Humanity. "Habitat ReStores." http://www.habitat.org/restores/default.aspx (accessed November 1, 2010).

[142] O'Brien & Company. "A Contractor's Waste Management Guide: Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawaii," (Honolulu: State of Hawaii Department of Business, Economic Development, and Tourism's Clean Hawaii Center), 5.

[143] Chris Lee, State *of Hawaii Representative, District 51 (Lanikai, Waimanalo)*, interview by author, November 23, 2010.

Table 6: Hawaii's Waste Management Resources[144]

BUSINESS NAME	PRODUCTS FOR SALE	ADDITIONAL SERVICES
Island Demo	N/A	Deconstruction, C&D waste sorting for recycling
Base Yard Hawaii Re-use Facility	Re-use/surplus construction materials & fixtures	Re-use and surplus material warehouse
Schnitzer Steel (Formerly Hawaii Metal Recycling)	N/A	Shredding/processing of cars, refrigerators and demo materials for shipment to mainland/China (Kapolei, Oahu & Puunene, Maui)
Grace Pacific	Pavement	Incorporates recycled asphalt and crushed glass into new pavement (glasphalt)
Re-Use Hawaii	Re-use/surplus construction materials & fixtures	Deconstruction, reuse and surplus material warehouse
Unitek Solvent Services	Fuel, landscaping products	Shreds and burns tires for fuel; crumbles rubber for use in landscaping products
AES	Fuel, landscaping products	Shreds and burns tires for fuel; crumbles rubber for use in landscaping products
Hawaiian Earth Products	Compost, mulch	Creates compost and mulch from green waste
Island Shell	Hydro-mulch, "InCide" cellulose insulation	Recycles paper into hydro-mulch, used oil boxes, and pest-control cellulose insulation

Although there are a number of retailers who sell products that contain recycled content in the islands, more times than not, these products are not remanufactured in the islands. From a cost and waste management stand point these products do not necessarily have a direct impact on Hawaii's waste management initiatives.

[144] State of Hawaii Department of Business, Economic Development, and Tourism Strategic Industries Division. "Buy Recycled in Hawaii: Product & Services Directory," http://www.opala.org/pdfs/solid_waste/buy_recycled_in_hawaii.pdf (accessed November 18, 2010).

Online Exchange Networks

Online exchange networks are another method of obtaining re-usable and secondhand building materials. These are online networks that connect people who are looking to get rid of used items with people who are looking for these specific items. Presently, there are no online exchange networks that are specific to building and construction materials. Maui Recycling Group used to manage the Hawaii Materials Exchange Network (also known as HIMEX) but lost much of its funding sources over time.[145]

The Aloha Shares Network (http://www.alohashares.org/) is an online exchange network currently run by the Maui Recycling Group that matches material donations to nonprofit organizations in need of items. Donations are accepted from anyone in the community, including businesses, organizations, individuals and government agencies and are not limited to building materials. However, recipients must be non-profit organizations if donors require a tax receipt as the Aloha Shares Network does not provide tax receipts. This service, provided by the Aloha Shares Network is free to both donors and recipients and the donors may not charge recipients of the donated materials. According to its website, the program has diverted a total of 54.5 tons of waste from landfills in 2010.[146]

Freecycle (http://www.freecycle.org/group/US/Hawaii) is another online exchange network available to Hawaii residents. However, Freecycle divides its network based on certain locations (Kauai County, Maui County, Big Island, Hawaii Kai, Schofield, and Honolulu) to encourage more locally-based exchanges.

The U.S. Environmental Protection Agency has a list of international and national exchange networks (http://www.epa.gov/epawaste/conserve/tools/exchnat.htm).

Reused/Reclaimed Materials

As stated earlier, reused materials are materials that have been extracted from the waste stream and repurposed with little or minimal reprocessing.

In their *Design for Reuse Primer,* Public Architecture, a San Francisco-based non-profit organization aiming for better 'design for the public good', recommends some general strategies for utilizing reused materials for a new construction project. First, they recommend strategizing for material reuse early in the planning phases of the project in order to navigate challenges and capitalize on benefits. It is also important to involve all stakeholders involved on the project during the discussion of material reuse.

Reuse projects also need to utilize a relatively high amount of flexibility particularly in writing specifications and expectations of material appearance. Some qualities should not be compromised such as structural quality, indoor air quality, energy efficiency, and storage

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[145] Jeff Stark, *Former Manager of HIMEX and Maui Recycling Group Programs,* email message to author.
[146] Aloha Shares Network. "How Effective is ASN?" http://alohashares.org/about-us/how-effective-is-asn/ (accessed May 3, 2012).

requirements, but some flexibility needs to be allowed in order to keep the project on time and on budget, since reused materials are not always consistent in appearance or available in large quantities. Furthermore, there needs to be a clear understanding of who is responsible for sourcing, providing, decontaminating, refurbishing, modifying, and installing the reused materials in order to ensure easier and more accurate bidding from subcontractors.

Although some reuse projects obtain materials from on-site deconstruction, certain items may not be available or salvageable. Therefore, It is also valuable to build relationships with reclaimed materials stores, suppliers and brokers in order to become familiar with their inventory and allow those people to become better acquainted with a project's needs. Engaging with these suppliers early on gives them enough time to identify, source and procure reclaimed materials that are of particularly important to a project, which helps to keep the project on schedule.[147]

The cost of reusing materials does not always result in monetary savings. Sometimes using reclaimed materials produces upfront savings, especially if materials are obtained during on-site deconstruction, particularly if the materials have been well preserved. Other times, the amount of additional labor needed to refurbish or refinish the salvaged materials may outweigh the initial savings. But reuse can be a way to build with high-quality materials that would be significantly more expensive if purchased new. Other times, reclaimed materials can be more expensive than new materials but add value to a project by meeting a client's aesthetic, environmental, or functional desires and goals.[148]

Wood is the most common form of reclaimed materials and its market's infrastructure has improved greatly within the last decade. Much of reclaimed wood is old-growth lumber which usually has a higher quality than new lumber sold today. Sources for reclaimed wood include deconstruction contractors, reuse retailers and specialty retailers. Certified wood graders are helpful to have on-site to determine the grade and quality of reclaimed wood from on-site deconstruction and structural engineers should be consulted when using reclaimed wood (or any other reclaimed material) for structural purposes. Other common reuse materials include brick and metal, as well as various specialty items such as carpet, granite slabs, lighting fixtures, etc.

During the 1990s, when it was beginning to gain momentum, the recycling market often faced issues (such as code compliance, lack of sufficient and consistent supply and demand, and lack of experience) that prevented the development of the industry. The reclaimed materials market now faces similar obstacles. However, Public Architecture believes the development of the reclaimed materials' market infrastructure following similarly to the maturation of the recycled

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[147] Public Architecture. "Design for Reuse Primer."
<http://designforreuse.org/design_for_reuse/DesignForReusePrimer.pdf> (accessed November 1, 2010), 5-8.
[148] Ibid, 9.

materials' market which has become almost commonplace.[149] They believe that increasing awareness of the reused materials market will help overcome many of these obstacles.

The re-use and salvaged materials market in Hawaii is limited but could possibly have considerable growth potential. According to Selina Tarantino, co-founder of Re-Use Hawaii, introducing the re-use industry to Hawaii received very little support from the government. Fortunately though, Hawaii residents recognize the deal they are getting purchasing salvaged material from old homes. They recognize the value of the material, especially in the high-grade lumber such as redwood tongue-and-groove boards which were once used for single-wall construction in older Hawaii homes.[150]

Honolulu has several re-use material warehouses but the largest and most publicized is Re-Use Hawaii. Other re-use locations include BaseYard Hawaii which operates in conjunction with the Nanakuli Housing Corporation. Habitat for Humanity also has a re-use and surplus material ReStore that supplements their non-profit, self-help organization. The premise for re-use stores being associated with non-profits is based on the need for donated inventory. By being a not-for-profit organization, these companies are able to issue tax write-offs to homeowners who are essentially donating salvageable materials and fixtures. These donations become re-use stores' inventory.

Recycling Buildings

Rehabilitating or reusing entire buildings is often considered the ultimate form of recycling in the building industry. The historic preservation movement, although more concerned with the historical significance of a place, is a huge advocate for saving old buildings from ultimately ending up in landfills. There are different methods of addressing treatment of historic buildings including preserving it in its received state or restoring it to a particular time in its history. Preservation of historic buildings can qualify for tax credits but in order to do so, they must be listed on the National Register of Historic Places and its treatments must be in compliance with the Secretary of the Interior's Standards.

Of all the different treatments for historic sites, rehabilitation is the most useful treatment as it involves making improvements to historic buildings in order for them to be useable again. Rehabilitation of historic properties can also qualify to receive federal and sometimes state tax credits, one of which can be combined with the Low-Income Housing Tax Credit if used for low-income housing.[151]

It must be made clear that this project does not intend to pass itself off as "preservation" despite its proposal to re-use old buildings. There is a difference between "old" and "historic" and that is historical significance. A building that is either architecturally or historically important

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[149] Ibid (Public Architecture), 11.

[150] Selina Tarantino, *Co-founder of Re-Use Hawaii*, interview by author. November 19, 2010.

[151] William F. Delvac. "Affordable Housing Through Preservation: A Case Study Guide to Combining the Tax Credits." (Washington D.C.: U.S. Department of the Interior, 1994).

is a building worth being preserved. The core purpose of historic preservation is to preserve a piece of history. A historic building can be updated and modernized to make it more relevant to its current time and place, but ultimately maintains its historical character.

The purpose of this project however is to propose a form of housing that is responsive and relevant to today and tomorrow. In doing so, its character is likely to change and evolve over time. The project is ultimately a form of adaptive reuse which refers to the reuse of a building for purposes different from its original intent. The most common form of adaptive reuse that is becoming more commonplace is the conversion of old industrial warehouses to residential lofts (also known as loft conversions). The selling of these lofts are sometimes sold as “raw” or unfinished space which is less expensive than finished spaces and allows its occupants to outfit their homes as desired.

An example of residential adaptive reuse in Hawaii is the Vanguard Lofts in Kaka‘ako which converted the former National Cash Register office into a mixed-use urban loft project.[152]

Image 31. Rendering of the Vanguard Lofts, Honolulu, Hawaii[153]

Existing buildings that are undergoing repair, alterations, or additions and change of occupancy are allowed to comply with the International Existing Building Code (City & County of Honolulu 2002).

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[152] *The Vanguard Lofts.* <http://thevanguardlofts.com/the-vanguard/> Accessed 09 January 2012.

[153] <http://www.thevanguardlofts.com/the-vanguard/> Accessed 11 January 2012.

Trajectory of Hawaii's Recycling Industry

Recognizing that Honolulu is a high consumer of materials with limited local resources, the City and County of Honolulu has been slowly but steadily pushing for the development of its waste management industries, including recycled materials and composting beginning with the first curbside newspaper recycling program in 1974. Although it was met with low participation rates and the program died off within a few months, recycling initiatives picked up again in 1989 with the hiring of the City's first Recycling Coordinator that became a catalyst for Honolulu's recycling programs including more curbside recycling programs in other districts around Oahu and the school/community recycling program.[154] In the 1990s, the City also began placing disposal restrictions and eventually disposal bans for businesses and government agencies on several targeted waste items. These items include green waste, electronic waste, cardboard, tires, auto batteries, scrap metals, and glass containers from bars/restaurants.[155]

During the 1990s, the State of Hawaii seemed to be particularly interested in the promotion of various recycling programs in Hawaii, including managing construction and demolition waste. At that time, the State produced several reports and guidebooks such as the Hawaii Recycling Industry Guide which was essentially a list of all the existing recycling programs throughout the state (private, public, and non-profit) that included contact information and indicated what types of materials each company or organization recycled. Unfortunately, the guide has not been updated recently and some of the programs such as HIMEX are no longer in operation due to lack of funding.[156]

Unfortunately, the focus of Honolulu's recycling efforts seem to have more recently focused on the collection of household waste such as paper, aluminum cans, glass bottles, and cardboard instead of construction and demolition waste. This may be because construction and demolition waste can be considered as materials with direct economic value and have generally been recycled for a long time. Therefore, the City's efforts toward recycling have been aimed at getting the public more aware of recycling low-value materials such as materials found in household solid waste. Limited existing manufacturing facilities for recycled product also may not provide much an incentive for the construction industry to take a greater interest in recyclable building materials in the islands.

According to State of Hawaii District Representative, Chris Lee, one of the main hurdles that the State has faced when mandating or encouraging C&D waste reduction in the past is opposition

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[154] Robert Young. "Garbage in Paradise: A History of Honolulu's Refuse Division." *Opala.org.* 1993. <http://www.opala.org/solid_waste/archive/History%20_Garbage_in_paradise.html> (accessed November 16, 2010).

[155] City and County of Honolulu Department of Environmental Services. "Mandatory Recycling." http://www.opala.org/solid_waste/archive/Mandatory_Recycling_Laws.html (accessed 16 November 2010).

[156] Jeff Stark, *Former Manager of HIMEX and Maui Recycling Group programs,* email message to author, November 3, 2010.

from builders and contractors. The economic recession had at one point put a halt on many major new construction projects in Hawaii, creating high competition for new construction projects that were requesting bids. It was argued by many local contractors that sorting demolition debris and/or employing methods of deconstruction would add additional time and labor costs to a project, making their bids less competitive.[157]

With the exception of steel and concrete, most construction and demolition waste still ends up in landfills. While most construction and demolition waste has the potential to be recycled, Hawaii doesn't have local recycling plants available to make a recycling industry feasible. Materials that have high recycling potential (like steel and other metals) are only collected locally and shipped to mainland recycling plants. This does nothing to affect transportation costs associated with building materials sold in Hawaii. With the negative environmental impacts recycling involves and the high importance of Hawaii's natural environment, it is unlikely that government or the public would support the growth of local recycling plants in the islands in the near future without significant reforms in the materials industry.

Reuse over Recycling

Recycling involves significant processing to convert post-consumer or construction and demolition waste materials into new products. The reprocessing of a building's steel beams into new beams or the crushing of glass and old concrete for use as aggregate for concrete and paving applications are a few examples of conventional recycling practices. Recycling (compared to reuse) is often highly energy and labor intensive because they reprocess old products into new ones.

> *During recent years, this golden principle [the three R's: Reduce, Reuse, & Recycle] has pretty much gone out the window: recycling has been boldly promoted to the number one slot, while its relegated counterparts - reduce and re-use - are now seldom discussed, let alone implemented. Governmental legislation often serves to drive recycling initiatives rather than re-use or reduction strategies, as recycling is more immediately compatible with economic growth in its current form.* [158]

While this observation by Jonathan Chapman has merit in the mainland U.S., as seen in the previous chapter, a recycling industry has yet to emerge in Hawaii despite government support. One of the reasons is that highly covets the quality of its environment. Any threat to it from development or industry would result in high opposition (and in turn resistance) from both the public and government.

Another issue with recycling is the retention of high-quality 'raw' material. During recycling, many high-quality materials are often contaminated by other materials that negatively affect

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[157] Chris Lee*, House Representative - District 51 (Lanikai, Waimanalo)*, interview by author, Honolulu, HI, November 23, 2010.

[158] Jonathan Chapman. *Emotionally Durable Design: Objects, Experiences & Empathy.* (London: Earthscan, 2005), 171.

performance properties of the original material. In their book *Cradle to Cradle,* architect William McDonough and chemist Michael Braungart use the following example of recycling metals from an automobile to demonstrate this point:

> *Currently, when an automobile is discarded, its component steel is recycled as an amalgam of all its steel parts, along with the various steel alloys of other products. The car is crushed, pressed and processed so that high-ductile steel from the body and stainless steels are smelted together with various other scrap steels and materials, compromising their high quality and drastically restricting their future use. (It can't, for example, be used to make car bodies again.) The copper in its cables is melted into a general compound and lost to specific technical purposes – it can no longer be used as copper cable.*[159]

As a solution to this problem, McDonough and Braungart recommend a reform of industrial design practices in order to create products that are designed for guilt-free disposal or rather, that these products, at the end of their usable life, can be reclaimed as "food" for either the biological systems or technical systems. For organic material such as paper and wood products, this would involve creating toxic-free, safely compostable products, which McDonough and Braungart call "products of consumption". Meanwhile inorganic materials, such as plastics, metals, and other non-biodegradable materials, are to be handled as "products of service" in which consumers are paying for the use of a product rather than the product itself. These are more applicable for products such as electronics that have a high obsolescence rate whose physical durability outlasts its usability. In this case, manufacturers, rather than consumers, handle their own product's disposal allowing manufacturers to separate the components of their products for more efficient recycling.[160]

Reused materials, on the other hand, are materials that are extracted from the waste stream and repurposed with little or no additional reprocessing. Examples of reused or reclaimed materials include old bricks that are cleaned of their mortar and used for a new façade or wood beams that are milled into flooring. With reused and reclaimed materials, the materials' existing nature and age is relatively preserved. Reused and reclaimed materials depending on its age can carry a patina that creates unique colors or textures and can convey a sense of antiquity that may be desirable. These qualities are often difficult to retain during the recycling process as its products are intended to be new.

In addition to inconsistent supplies, one of the reasons that re-use market has had a difficult time growing is that from the demand side, many people perceive used building materials as

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[159] William McDonough and Michael Braungart. *Cradle to Cradle.* (New York: North Point Press, 2002), 110-111.

[160] William McDonough and Michael Braungart. *Cradle to Cradle.* (New York: North Point Press, 2002), 93-117.

having a lower quality than their new equivalents.[161] This perception can arise because of aesthetic reasons such as nail marks that cause people to question the structural integrity of a material or it could do with health concerns such as risking potential exposure to lead-based paint or asbestos.

Lifecycle Building

Lifecycle building is a design movement that has emerged in the face of the 'green building'/sustainability movement in architecture that has gained popularity in recent years. The focus of lifecycle building is 'the design of building materials, components, information systems, and management practices that facilitate and anticipate future changes to and eventual adaptation or dismantle and recovery of all systems, components and materials.'[162]

Lifecycle building goes beyond specifying salvaged materials or materials with recycled content. Although the concept of lifecycle building has strong roots in construction and demolition waste management considerations, it also extends further into the realm of flexible building design and building rehabilitation. Its design considerations include designing for deconstruction, adaptable architecture, and sustainable management of buildings.[163]

In prior chapters, this project discussed reasons why and methods on how to achieve flexibility in building and housing design. Therefore, the discussion on lifecycle building will focus primarily around the concern for waste management practices and strategies.

There are several schools of thought in regards to lifecycle building. Most of the research of the term 'lifecycle building' that was investigated by this report centered on building and material reuse and designing for deconstruction. However, lifecycle design also applies to realms of recycling and initial waste reduction as well. The following section describes three different broad scale approaches toward lifecycle building design.

Designing for Deconstruction

As stated earlier in this section, Hawaii would benefit more from a reused materials industry than a local recycled materials industry given existing economic and industry conditions. In order to support local reuse warehouses and other salvaged material suppliers, the way that

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[161] U.S. Environmental Protection Agency Pollution Prevention Office. "Lifecycle Construction Resource Guide," under "Lifecycle Building Challenge," http://www.lifecyclebuilding.org/files/Lifecycle%20Construction%20Resource%20Guide.pdf (accessed October 3, 2011).

[162] "About Lifecycle Building." *Lifecycle Building Challenge.* < http://www.lifecyclebuilding.org/> (accessed March 9, 2012).

[163] *Lifecycle Design of Buildings, Systems and Materials.* Conference Proceedings of CIB W115 Construction Materials Stewardship. Enschede, the Netherlands, June 12-15, 2009.

buildings in Hawaii need to be designed in such a way that they can be easily deconstructed or disassembled to maximize the amount of salvageable material from a site.[164]

Designing for deconstruction or disassembly (also known as DfD) is the design of building in such a way that it can be deconstructed or disassembled and its components reused or recycled at the end of a its useful life. Buildings that are designed for deconstruction or disassembly are typically easier to maintain and adapt to new uses, encouraging recycling and re-use on a larger scale and ensuring new structures have a smaller environmental impact. They also help reduce the time and labor costs for deconstruction contractors through ease of assembly, provide more usable material for new construction and inventory for re-use stores and warehouses, and generally provide a local source of construction materials.

Recommended Practices of DfD

The preferred method of designing for deconstruction involves simple construction of high-grade, durable materials and avoiding permanent or hard to remove adhesives that damage materials upon removal. Typically screwed or bolted assembly is preferred for easy disassembly. Mechanical fasteners and releasable adhesives are also recommended alternatives to conventional adhesives and sealants. For masonry buildings, traditional lime mortars are recommended rather than conventional Portland cement-based mortars because the lime mortars are softer than the brick and easier to remove. Precast concrete members also are preferred because they have a much greater reuse potential than cast-in-place structures.

Challenges in deconstruction and dismantling tend to occur with more complex and integrated building systems. Buildings with hidden building systems or components require more consideration to deconstruct because the true nature of the building and its systems is unknown. For example, it is impossible to see how concrete structural members are reinforced from the outside, lacking information such as strength and serviceability necessary to structural engineers to be able to reuse the member.

When designing building systems using DfD principles, generally, easily identifiable systems that are layered (rather than integrated) are preferred for ease of disassembly. Labeling structural members with material grade, species (for wood), or other information can help with identifying reusable material and determining its new purpose. Separation of structural systems from electrical, plumbing and mechanical systems better ensure their components' reusability. For example, if electrical wiring and plumbing are threaded through wood framing, this makes deconstruction more difficult and reduces the reuse value of the framing member.[165]

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[164] Selina Tarantino, *Reuse Hawaii.* Interview with Author. November 19, 2010.

[165] Webster, Mark D. and Daniel T. Costello. "Designing Structural Systems for Deconstruction: How to Extend a New Building's Useful Life and Prevent it from Going to Waste When the End Finally Comes," paper presented at GreenBuild Conference, Atlanta, GA, November 2005. http://www.lifecyclebuilding.org/files/Designing%20Structural%20Systems%20for%20Deconstruction.pdf (accessed December 7, 2010)

Furthermore, mixing material grades also makes reuse more difficult especially if materials are not labeled. Using the same grade of material makes sorting material easier and generally has a higher resale value.

Building systems that consistently use standard components in regular intervals have a higher reuse value than buildings using irregular or custom-made components. This is because standardized or consistent components fit easier into new projects than custom-fitted, one-of-a-kind pieces. For this reason, panelized systems are generally regarded as being helpful in DfD projects because they are modular and are basically an assembly of consistent and standardized components. Panelized wall systems have the potential to either be re-used as a panel or it can be easily dismounted and deconstructed on the ground, making its components reusable.

Cradle to Cradle Design

The term 'cradle to cradle' is a term coined by architect William McDonough and chemist Michael Braungart that refers to the designing of products and buildings in such a way that they become 'food' or nutrients either for new products or the environment. McDonough and Braungart's 'cradle to cradle' principles fall primarily in the recycling spectrum of lifecycle building design considerations although discussions in their book *Cradle to Cradle* also expand into the realm of architecture suggesting that buildings can also 'be restorative: like a tree, they can purify water, and send it out into the landscape in a purer form, accrue solar income for their own operations, provide habitat…and give back to the environment.'[166]

However, McDonough and Braungart's most compelling ideas have to do with revolutionizing the material and product recycling industry. According to McDonough and Braungart, one of the biggest challenges recycling faces is product designers and manufacturers not designing their products for recycling. Organic materials and materials that have the potential to be biodegradable and easily compostable are often contaminated by chemicals for bleaching, toxic inks, and fungicides that make it unsafe to handle. Nonorganic materials (such as metals and plastics) and are also often contaminated during the recycling process because their products were not designed to be recycled. Materials need to be separated to maintain its high quality, virgin-like qualities but often times in recycling, metals and plastics are melted together with other paints, plastics, and coatings that result in a 'hybrid of lower quality'[167] which requires additives to restore desirable performance quality.[168]

To design for recycling means that one must address material flows; in particular, designing products in a way that provide either 'biological' or 'technical' nutrients. Biological nutrients are nutrients that are useful to the biosphere and can be consumed by microorganisms and animals,

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[166] William McDonough and Michael Braungart, *Cradle to Cradle,* (New York: North Point Press, 2002), 183-184.

[167] William McDonough and Michael Braungart, *Cradle to Cradle,* (New York: North Point Press, 2002),56.

[168] William McDonough and Michael Braungart, *Cradle to Cradle,* (New York: North Point Press, 2002),58.

while technical nutrients are useful to systems of industrial processes.[169] Most materials and products today are what McDonough and Braungart refer to as 'monstrous hybrids' – mixtures of materials both technical and biological, neither of which can be salvaged after their current lives.'[170] Instead McDonough and Braungart recommend that each material flow – biological or technical – be treated differently and kept separate. Biological nutrients should remain organic, compostable, nontoxic, and be designed for guilt-free disposal. Essentially they can be thrown on the ground and left there with no environmental repercussions.[171] Technological nutrients on the other hand are inorganic, highly durable, and incapable of biodegradation. Because technology is ever changing, ever evolving, ever upgrading, products containing technological nutrients should be treated as products of service – meaning that manufacturers should be responsible for the waste management of these materials and therefore in control of the separation and retention of these high-quality materials.[172]

Emotional Durability

One drawback of McDonough's and Braungart's proposal is that their solution is based on the assumption that wasteful behavior is okay as long as the waste is non-toxic or recyclable. What happens though if wasteful behavior is encouraged to the point where we're consuming and disposing products at a faster rate than these biodegradable products are able to compost?

Jonathan Chapman proposes an alternate solution and believes that designing to discourage wasteful behavior should be given equal consideration as a waste management strategy.

> *[Current] sustainable design methodologies lack philosophical depth, adopting a symptom-focused approach comparable with that of Western medicine… Sustainable design has developed a tendency to focus on the symptoms of the ecological crisis rather than the actual causes. In consequence, deeper strategic possibilities are overlooked which if developed might build further value into existing creative methodologies. By failing to understand the actual drivers underpinning the human consumption and waste of goods, sustainable design resigns itself to a peripheral activity, rather than the central pioneer of social change that it could potentially be.* [173]

Chapman suggests instead discouraging wasteful behaviors by designing products in such a way that forms lasting relationships between consumers and their possessions. While Chapman's arguments are intended more towards product and technological design rather than

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[169] William McDonough and Michael Braungart, *Cradle to Cradle,* (New York: North Point Press, 2002), 93.
[170] William McDonough and Michael Braungart, *Cradle to Cradle,* (New York: North Point Press, 2002), 98-99.
[171] William McDonough and Michael Braungart, *Cradle to Cradle,* (New York: North Point Press, 2002), 105-109.
[172] William McDonough and Michael Braungart, *Cradle to Cradle,* (New York: North Point Press, 2002), 109-114.
[173] Jonathan Chapman, *Emotionally Durable Design: Objects, Experiences, & Empathy.* (London: Earthscan, 2005), 9-10.

architecture or buildings, per se, certain arguments presented can bridge the gap. Of particular relevancy are Chapman's explanations of consumer motivation, causes of obsolescence and waste, and the creating and sustaining product narrative.

Designing for emotional durability essentially involves creating and maintaining a narrative or story that reflects the care invested by the user onto the designed product[174] which in our case would be housing. In order to create a narrative that resonates with any user, it is important for the designer to leave some room for the user to imbue a part of his or herself into the product and have the product physically reflect this personal investment. Leaving space for the user is important in emotionally durable design because it allows for spontaneity. Spontaneous interaction between subject and object (in our case, housing) allows the user to bring their own preconceptions, beliefs, and ideals into the engagement, making the experience unique and special to a particular individual. Chapman uses the examples of houseplants, vintage cars, and denim jeans to illustrate his idea of objects that retain sustainable narratives and reflect user interaction.[175]

Like McDonough and Braungart, Chapman acknowledges the problematic relationship between organic and inorganic materials in today's products. However, Chapman's concern focuses more around the fact that 'ungraceful ageing is frequently the precursor to waste'[176] and instead recommends the employment of what he calls 'desirable aging strategies.' Although he does not go specific examples of what these strategies might be, he does imply that these strategies could involve taking advantage of patinas, weathering, decay and distress (scratches, dents, dings, etc.) in such a way that 'challenge our social desire for a scratch-free world.'[177] Chapman warns however against using the notion of the use of patina as a 'bolt-on afterthought':

> *If the presence of patina draws too much attention to itself, consumers will perceive the resulting experience as pre-programmed and inauthentic, ramming a colossal wedge between subject and object…It is therefore imperative that patina is seen as a co-dependent element of the whole, rather than a one-stop approach to durable product design.*[178]

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[174] Jonathan Chapman, *Emotionally Durable Design: Objects, Experiences, & Empathy.* (London: Earthscan, 2005), 111-136.
[175] Jonathan Chapman, *Emotionally Durable Design: Objects, Experiences, & Empathy.* (London: Earthscan, 2005), 112-113
[176] Jonathan Chapman, *Emotionally Durable Design: Objects, Experiences, & Empathy.* (London: Earthscan, 2005), 129.
[177] Jonathan Chapman, *Emotionally Durable Design: Objects, Experiences, & Empathy.* (London: Earthscan, 2005), 130.
[178] Jonathan Chapman, *Emotionally Durable Design: Objects, Experiences, & Empathy.* (London: Earthscan, 2005), 131.

Although Chapman's notions of emotional durability are not necessarily recognized by the lifecycle building community, specifically, it is worthwhile effort to consider some of his arguments and opinions, especially when considering how to design in a way to avoid obsolescence in housing from a behavioral standpoint.

Chapman's arguments overlap with those of the flexible housing movement in that the designer (or architect) should not fully dictate how a user (or resident) interacts with a product (or space). In his book, *Building the Unfinished,* Lars Lerup asserts this idea by stating:

> *Human action, in the perspective of interaction, is a complicated matrix with unknown combinations – the result of which is considerable unpredictability, a marvelous unfinishedness and openness. When this fact is brushed aside, ignored or forgotten, the importance of architecture becomes simply utilitarian, design itself becomes dull, repetitive and mechanical. But more importantly, such a basis of design becomes absurd.*[179]

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[179] Lars Lerup. *Building the Unfinished: Architecture and Human Action.* Volume 53, Sage Library of Social Research, (Beverly Hills: Sage Publications, 1977), 21.

Material Considerations

In designing to perpetuate a reuse industry in Hawaii, material performance is an important consideration given that Hawaii's natural elements have a tendency to work against conventional Western building materials. If we ignore the effects of Hawaii's marine tropical environment on its buildings, the potential to reuse these materials evaporates. They become unusable and we perpetuate the 'cradle to grave' cycle that McDonough and Braungart are fighting against.

Hawaii's tropical marine environment creates several pressing concerns regarding the durability of certain building materials which has a direct impact on their ability to be reused. Humid salt air creates high rust and corrosion many metal products especially for homes located near the ocean. High humidity levels also increase mold and mildew growth and decay in wood products. The presence of both drywood and subterranean termites also wreak havoc on wood products, which often requires chemical treatment that jeopardizes reuse. Continuous sun exposure may rapidly fade vibrant colors from various paints and coatings.

Hawaii's physically isolative environment limits the amount and variety of locally available raw material needed for western methods of construction. Although native Hawaiians traditionally built with locally available materials such as lava rock, wood posts and thatch, these types of materials weren't considered suitable for western-style buildings because resources were either difficult to access or the cost to obtain them was considered unreasonable. As a result, Hawaii's reliance on importing most of its building material began steadily increasing especially with the increased use of steamships in the 1870s[180] and continues on today. Compounding this problem is the fact that oil prices continue to increase, which drives up shipping costs, and ultimately the cost of goods in the islands.

Despite the increasing cost and limited availability of locally available materials, many Hawaii residents still desire traditionally used materials like Hawaiian hardwoods, lava rock, and coral because of their association with creating a "Hawaii sense of place". Additionally, many residents who grew up in Hawaii have a nostalgic association with many older building materials that while not locally available raw material, are still considered "local" in the sense that they are associated with Hawaii's architectural vernacular.

During the 2011 Fall semester, the author of this paper conducted a research and analysis project on the reuse potential of several commonly used building materials in Hawaii residences. Appendix A includes a questionnaire used to evaluate each material type based on building systems (e.g. structure, roofing, siding, walls, and flooring). The questionnaire was divided into eight categories of grading criteria: Aging, Product Life and Durability, Installation Methods & Labor, Environmental Impact, Human Health Concerns, and Alternative Applications. The category of aging considered the material's aesthetic qualities over time such as whether the material patinas or discolors over time. Product Life and Durability dealt with the product

[180] Don Hibbard. *Buildings of Hawaii.*(Charlottesville: University of Virginia Press, 2011), 5-6.

strength and its resistance to wear and tear, abrasion, moisture, decay, insects, brittleness, and corrosion. Installation Methods and Labor addressed how the product was installed and whether this method allows for easy removal with minimal damage.

These criteria were derived from various Designing for Deconstruction manuals such as Mark Webster & Daniel Costello's "Designing Structural Systems for Deconstruction" and Public Architecture's "Design for Reuse Primer", as well as William McDonough and Michael Braungart's *Cradle to Cradle* principles for product design as 'food' for new materials.

From this questionnaire materials were graded on its potential for reuse in Hawaii's climate using a "high-moderate-low" system for each category. The grading categories were then combined graphically to show how the reuse potential for each material measures up to its alternatives. Three bars in one category indicates a "high" grade in that category, two bars indicate a "moderate" grade in that category, and one bar indicates "low" grade in that category. The following image summarizes the results of this study.

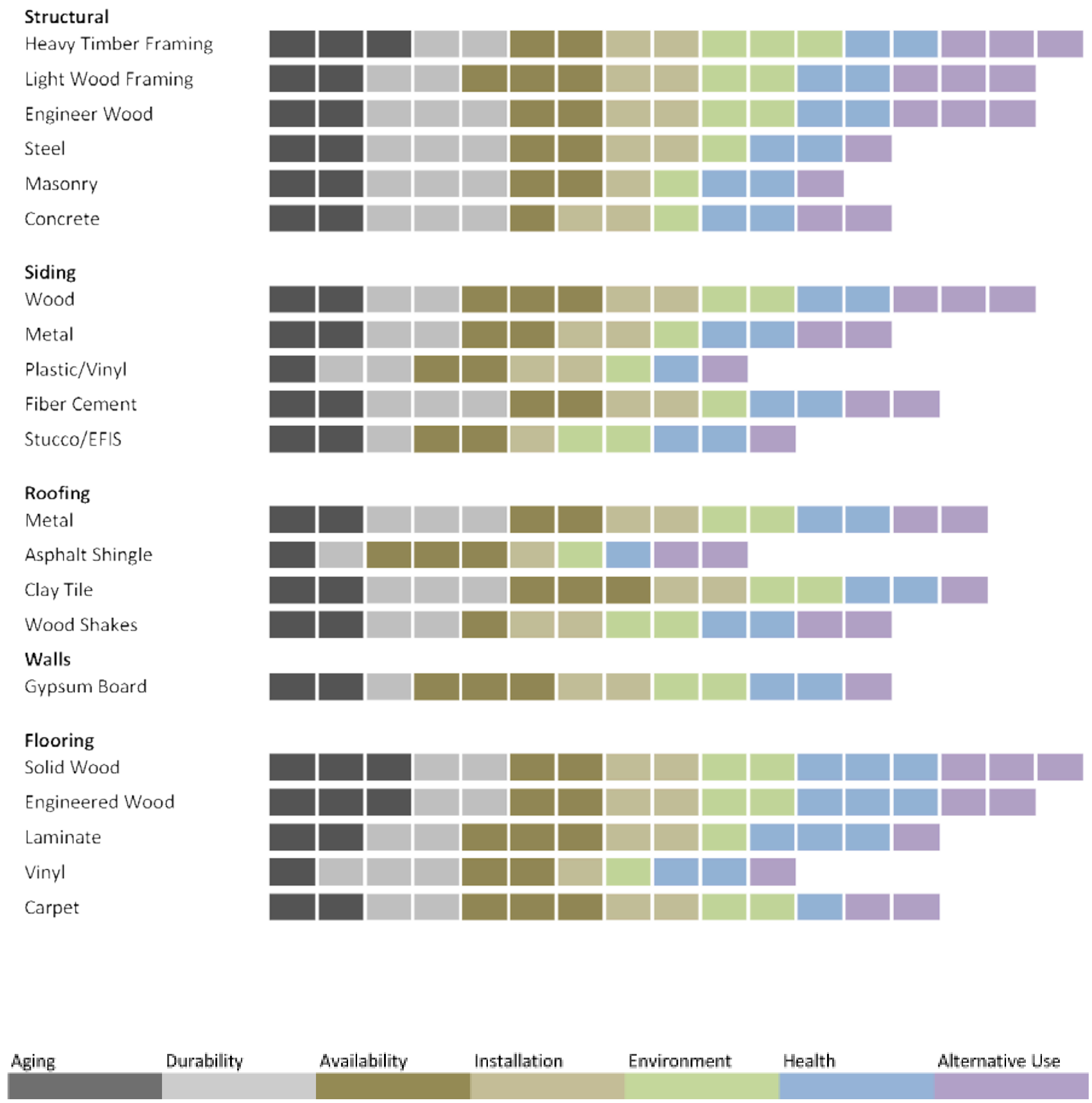

Image 32. Reuse Potential of Commonly Used Residential Building Materials in Hawaii[181]

The study was primarily done to inform material decisions during the design phase of this process which at the time had a high focus on building and material reuse. While the emphasis of the overall D.Arch project has now shifted to include the prefabricated and flexible housing approaches, designing for reuse is still worthwhile consideration because it still remains as a potential solution to supply locally available material resources in Hawaii. The idea and opportunity just needs to grow and to do so, buildings in Hawaii need to be designed differently to provide reuse resellers with abundant and more consistent inventory. Urban multifamily housing has the potential to provide a significant amount of reusable building materials and

[181] Image by Author.

components since there is a high level of standardization and uniformity involved in conventional multifamily housing design.

Shortcomings in Lifecycle Building

As mentioned earlier, this project's original hypothesis fell through when research through interviews and literature research revealed that given the current state of the recycling and reuse industries, Hawaii is unlikely to develop its own to become self-sufficient any time soon. While lifecycle building, in theory, is a viable option for Hawaii, the economic and environmental benefits of it will not be seen for quite some time. This is not to say that developing such a market for Hawaii would not be worthwhile, only that there are numerous obstacles for Hawaii to overcome.

The financial success of an adaptive reuse project is highly dependent on the existing conditions of both building and site. Inadequate infrastructure, hazardous materials, structural repairs, updating accessibility and code compliance, upgrading building systems, etc. can all add considerable cost to an adaptive reuse project. A significant amount of pre-design planning is needed to determine the scope of intervention that is to be applied to the existing building.

Retaining the quality of materials with high reuse and/or recyclable potential remains a constant struggle for the lifecycle building movement. A given climate and environment plays a huge impact on the weathering and durability of materials and often times solutions (often in chemical form) used to preserve and protect materials inadvertently reduce its reusability or recyclability.

Furthermore, a significant problem that cannot be ignored however is the favor of compound and composite materials by most building professionals, architects, and developers. The main reasons for this preference are the initial cost savings and the improved durability and reduced maintenance. Materials that have a high reuse potential are generally more expensive than its less reusable counterparts. For example, solid wood flooring has a higher reuse potential than laminate flooring but laminate flooring appeals to more consumers because it looks similar to wood flooring but costs a lot less. There is also less maintenance with laminates, an added bonus to the consumer. Taking this into consideration, it is unlikely that constructing new buildings out of materials with high reuse potential will occur. The problem however is that these materials are unsuitable for reuse. If the product cracks, delaminates, stains, fades, etc. it is unlikely that the effect will be desirable or appealing.

Consumer behavior almost always favors the new and shiny. Although there is a growing awareness and even nostalgic interest in using salvaged material, overcoming stigmas against 'secondhand' materials still remain an issue especially for structures and for housing applications. As a result, lifecycle building movement seems to cater toward 'new' or perceptively new products. Doing so often means that more energy is expended to recycle, remill, or refinish materials to achieve this perceived newness. A perhaps less energy intensive approach could strategizing an approach to incorporating salvaged materials so that they are located in places that residents feel are acceptable or they are somehow integrated with new materials.

2.4 Precedent Studies

The following precedent studies are examples discovered during literature research that were considered successful (or potentially successful) approaches toward balancing standardization with customization in housing design. These precedent studies were heralded as successful (or potentially successful) design approaches toward large scale design for each housing design movement.

Frank Lloyd Wright's Usonian Houses (Prefabrication)

Image 33. Frank Lloyd Wright's Usonian House for Herbert Jacobs (Madison, Wisconsin)[182]

Key Ideas: *Planning Grid (horizontal & vertical), Pre-cut home, Factory-made components (bricks, milled timber, joinery items – windows, doors, furniture), Site-specific.*

Frank Lloyd Wright's Usonian Houses were a series of homes built in the 1930s-40s that the architect envisioned for the 'average American family.' However, Wright's clients were journalists, academics, and business executives rather than factory workers.

According to Colin Davies, Wright's Usonian Houses carried a similar set of details through all of the designs, an '*ad hoc* continuity [that] became a thorough-going system.' These details included controlling a 4'-0" x 2'-0" horizontal planning grid, a vertical grid that conformed to both brick courses and standard milled timber sizes, and a book of standardized details to

[182] Photograph by David Heald, 2009. <http://0.tqn.com/d/architecture/1/0/_/t/JacobsHouse_exterior.jpg> (accessed May 1, 2012).

simplify construction.[183] Wright's Usonian designs were a justification of the logical 'system' of standardization for housing production rather than a prototype.

> *The system was not foolproof but it reduced 'on costs' (the cost of design) and it produced beautiful houses. Its potential for industrial production, however, was never realized…Wright was simply trying to rationalize his one-off houses. The irony is that of them all the Usonian was probably the house with the most mass-market potential.*[184]

Wohnanlage Genter Strasse (Flexible Housing)

Image 34. Wohnanlage Genter Strasse by Otto Steidle and Partners, 1972[185]

Key Ideas: *Excess Space, Support and Infill, Legibility, the Frame, Prefabricated Building System, Over-capacity.*

Wohnanlage Genter Strasse was designed by Otto Steidle and Partners in Germany in 1972. The project was designed and constructed in three phases with 7 units per phase. Although this building contains many of the flexible methods described by Schneider and Till, the key feature of this project is its demonstration of support & infill as well as legibility. It is because of this

[183] Colin Davies. *The Prefabricated House.* (London: Reaktion Books, 2005), 31

[184] Colin Davies. *The Prefabricated House.* (London: Reaktion Books, 2005), 33.

[185] "Wohnanlage Genter Strasse." *A Few Thoughts.* Companion website to Tatjana Schneider and Jeremy Till's book *Flexible Housing*. <http://www.afewthoughts.co.uk/flexiblehousing/admin/images/54/1.jpg> (accessed March 6, 2012).

legibility that it is one of the few projects in which the interiors, volumes, and uses have changed considerably over the last 30 years.

The first construction phase uses a structural support of a prefabricated concrete skeleton with corbels on every half-story onto which cross beams can be placed. The ability for these corbels to accept these crossbeams increases adaptability options – allowing for one-and-a-half or two story spaces. The skin of the building is a system of infill solid panels and windows that can be changed at will. The first phase of the building is more open and straightforward than the later phases in that its construction system is provides visual clues of flexibility and adaptability.

The second and third phases are slightly modified versions of the first phase in terms of the approach toward the structure and the infill. The second phase's frame uses the "Elementa" system which is a simplified reinforced concrete skeleton of columns with 'longitudinal downstand beams and ceiling panels.' This phase also utilizes prefabricated wet cores which also provide structural integrity. Phase three also uses a reinforced concrete skeleton but instead uses a customized infill cladding.

The architect also provided excess space at the beginning of the project which could be claimed over time. Structural connections expressed in the frame at every half-level allows for more complex spatial adaptation.[186] The concrete structure was also designed over-capacity which allowed for future vertical expansions on the roof or in previous unfilled spaces.[187]

[186] Tatjana Schneider and Jeremy Till. *Flexible Housing.* (London: Elsevier, 2007), 85.
[187] Ibid, 197.

Hollabrunn (Flexible Housing)

Image 35. Hollabrunn by Ottokar Uhl and Josef Weber[188]

Key Ideas: *Support + Infill, Modularity, Open Form, User-participation, Indeterminate design approach, Pre-occupancy adaptability*

Hollabrunn is a housing terrace project that was completed in 1976 in Austria. It was designed by Ottokar Uhl and Josef Weber. The project utilizes several methods of achieving flexibility but its primary approach was anticipating for user participation in the design. In its planning application, the project stated that that the exact number and types of units would be determined once the future occupants had designed them. The project is a prime example of what Schneider and Till refer to as a "soft" approach to design – using a frame structure, limited fixed elements (service and circulation core), modularity, prefabrication, as well as allowing for the user to design his/her own unit. Legibility was also another design element as the frames (made of prefabricated Lecca concrete columns and beams) visually expressed the extent to which one could extend his/her unit.

According to Avi Friedman, the project also involved a certain amount of preoccupancy adaptability in which the architect designed the basic structure and vertical service elements and occupants could choose the layout, sizing, materials and even façade treatment of their units. The architects also provided sample floor plans to occupants to assist with the development of their individual layouts when requested.[189]

Unfortunately, only half of the units were actually designed by the future occupants due to the fact that there were only 34 households that had expressed interest in the project when detailed planning began. Furthermore, the entire participatory process was said to add an additional 5% to the overall budget.[190]

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[188] <http://photo.net/photodb/photo?photo_id=3374622> (accessed March 13, 2011).
[189] Avi Friedman. *The Adaptable House.* (New York: McGraw-Hill, 2002), 39.
[190] Tatjana Schneider and Jeremy Till. *Flexible Housing.* (Amsterdam: Elsevier, 2007), 90.

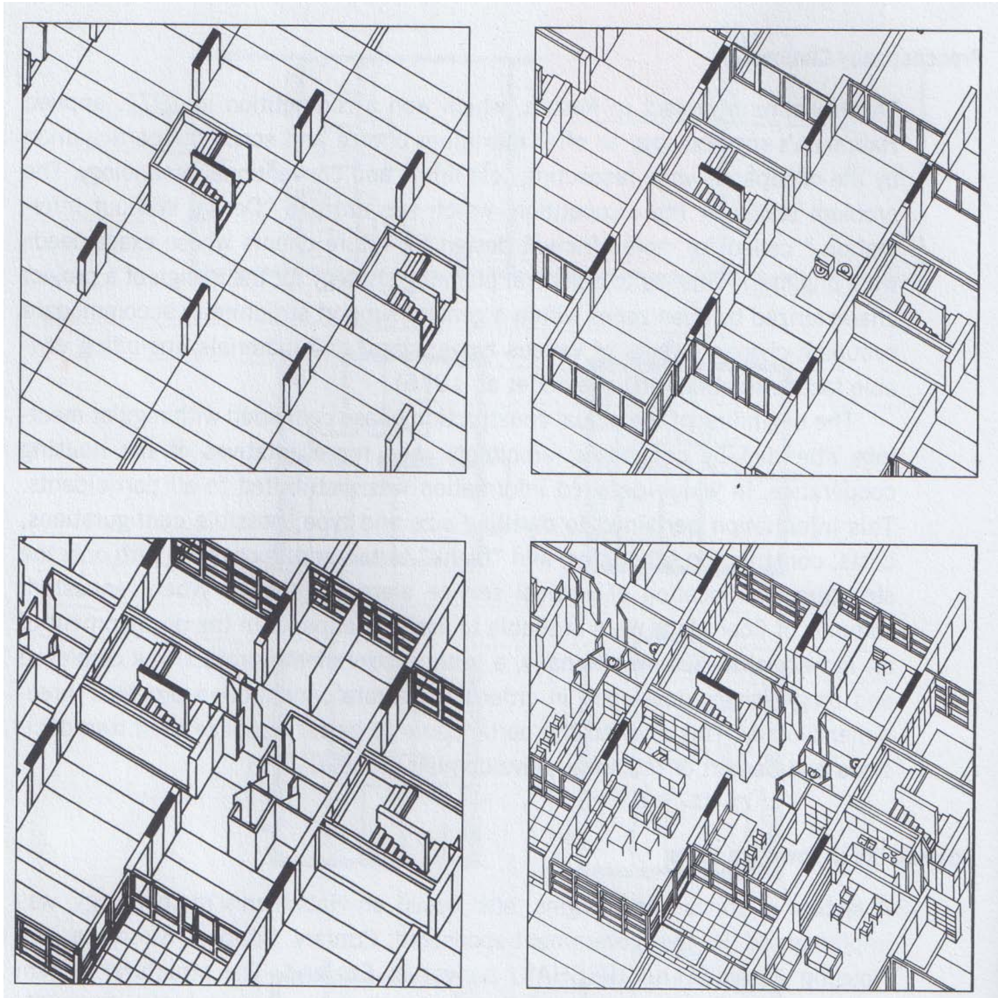

Image 36. Support Structure of Hollabrunn & Resultant Dwelling Layouts[191]

[191] Avi Friedman, "Support Structure in Hollabrunn, Austria." *The Adaptable House: Designing Homes for Change.* (New York: McGraw-Hill, 2002), 40.

The Work of KieranTimberlake Associates (Lifecycle Building)

The works of KieranTimberlake Associates are exemplary of many of the arguments presented throughout this paper. All of the projects use a combination of factory-built modules and panels that are assembled on site – a construction approach that benefits from cost and time efficiency from prefabricated elements but also allows a certain amount of design flexibility, while also considering the lifecycle of the building, its components, and its materials.

The Loblolly House

Image 37. Loblolly House by Kieran, Timberlake[192]

The Loblolly house, designed by KieranTimberlake Associates, is a particularly important case study in this project because it includes two key features: its prefabricated panelized construction method and its design with deconstruction in mind. The building is also a very good example of how a project can be both prefabricated but still site-specific.[193] The building is named after the loblolly pine forest where it is located in Taylor Island, Maryland and is built on stilts to minimize its impact on the site.

[192] Stephen Kieran and James Timberlake. "Figure 1.13: Twilight view of the west façade." *Loblolly House: Elements of a New Architecture.* (New York: Princeton Architectural Press, 2008), 35.

[193] Barry Bergdoll. preface to *Loblolly House: Elements of a New Architecture,* by Stephen Kieran and James Timberlake (New York: Princeton Architectural Press, 2008), 6.

Kieran and Timberlake's approach to prefabrication is to consolidate the numerous parts of the conventional American house into only several component types, streamlining the on-site assembly process. Their process is illustrated in Image 38 below.

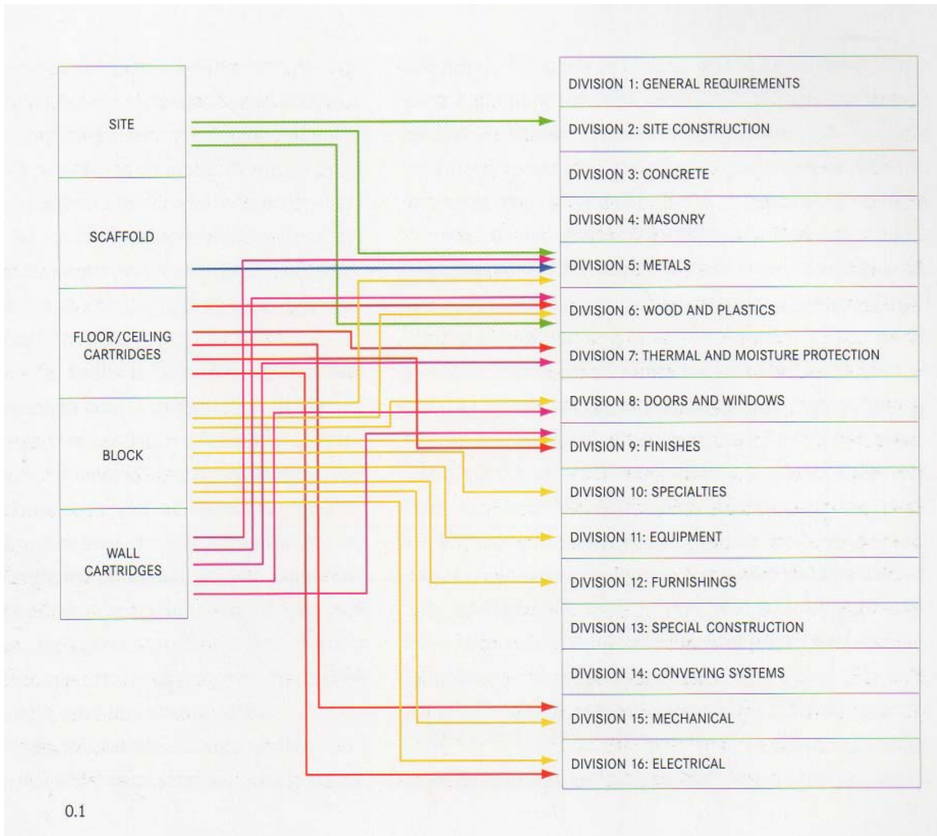

Image 38. Integrated Construction Elements of Loblolly House[194]

The resulting design involves an aluminum frame into which prefabricated "cartridges" or panelized systems are attached. Kieran Timberlake classifies its two panelized systems as "dumb" panels and "smart" panels. The "dumb" panels are typically structural, insulated, or partition walls that do not house any systems. The "smart" panels are typically floor panels that house heating, electricity distribution and outlets, and cooling micro-ducts. At the end of the building's life, these panels can be removed, the frame deconstructed, and the building can be reassembled or reconfigured on another site.

Key Ideas: *Support & Infill, Panelization, Designing for Disassembly, Prefabricated Kitchen/Bath Modules, Material Lifetime Consideration*

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[194] Stephen Kieran and James Timberlake. "0.1 The 40,000 parts that make up the average American House collapse into five integrated construction elements." *Loblolly House: Elements of a New Architecture.* (New York: Princeton Architectural Press, 2008), 66.

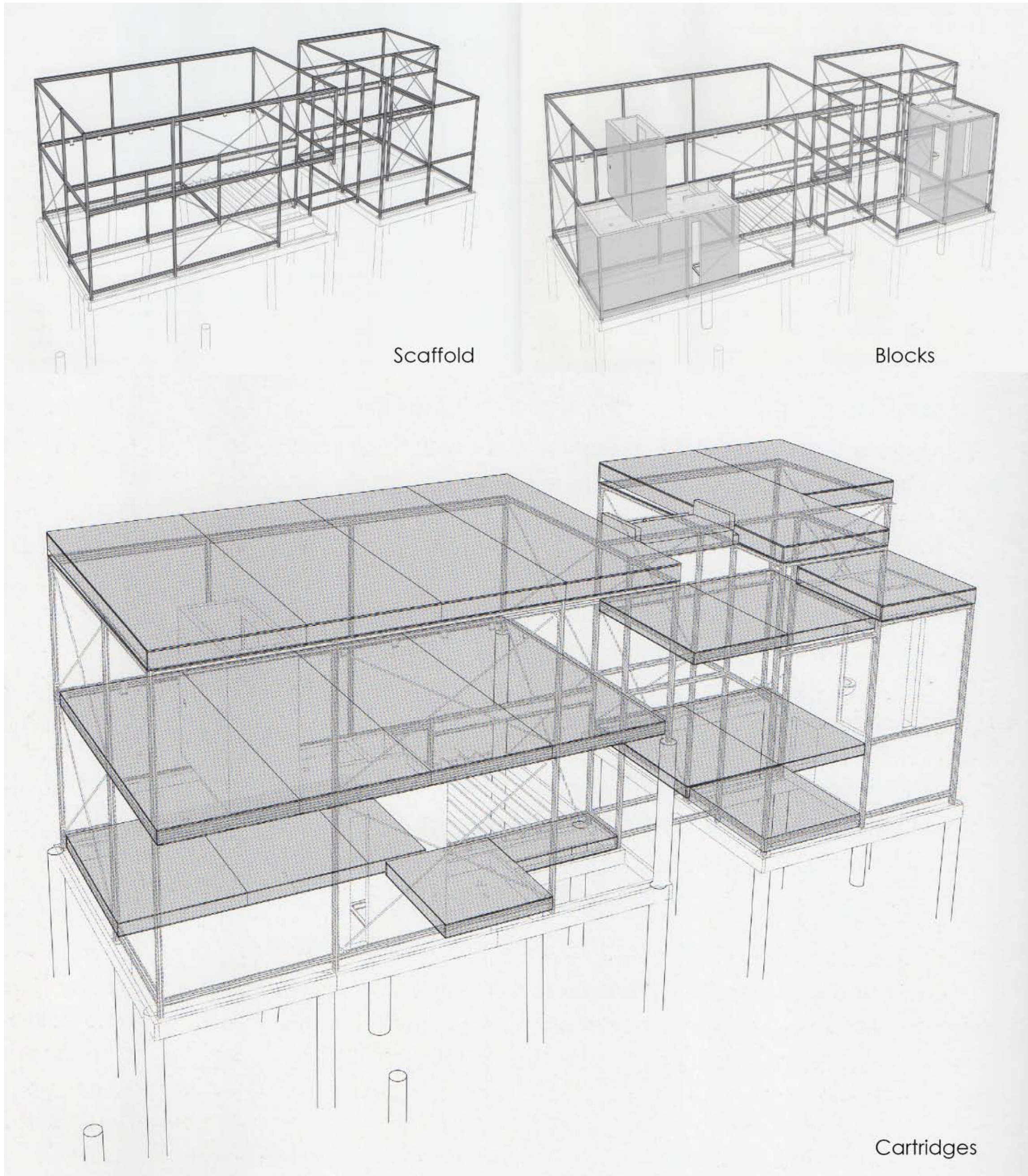

Image 39. Elements of the Loblolly House: Scaffold[195], Blocks[196], and Cartridges[197]

[195] Stephen Kieran and James Timberlake. "4.1 Parametric model of the aluminum scaffold and substructure." *Loblolly House: Elements of a New Architecture.* (New York: Princeton Architectural Press, 2008), 66.

[196] Stephen Kieran and James Timberlake. "6.1 Parametric model of mechanical, electrical, and plumbing blocks within the scaffold." *Loblolly House: Elements of a New Architecture.* (New York: Princeton Architectural Press, 2008), 102.

LivingHomes

LivingHomes is a Santa Monica-based developer of housing products who works in collaboration with KieranTimberlake to "direct developers and would-be homeowners to a customized end product, which the LivingHomes design team will adapt to given circumstances of climate, place, and budget."[198] The idea behind the design of KieranTimberlake's prototype for LivingHomes is a combination of 'dumb panels', like the Loblolly House (which are primarily structural and minimally include service distribution), and 'smart modules' which are prefabricated modular units that house vertical circulation, services and equipment. These two elements can essentially be combined in a number of ways, forming various combinations and housing types as seen in Image 41. Size variants and configurations of KieranTimberlake's LivingHomes PrototypeImage 41.

Key Ideas: *Prefabricated Modules, Panelization, Assembly/Disassembly*

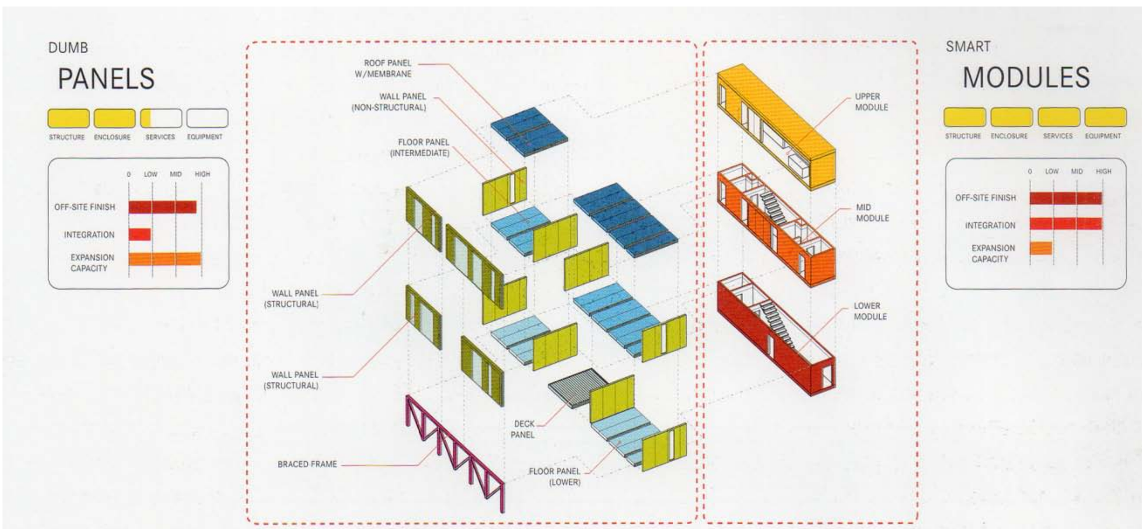

Image 40. Deconstructed diagram of KieranTimberlake's LivingHomes prototype[199]

[197] Stephen Kieran and James Timberlake. "5.1 Parametric model of floor and roof cartridges." *Loblolly House: Elements of a New Architecture.* (New York: Princeton Architectural Press, 2008), 82.

[198] Stephen Kieran and James Timberlake. *Loblolly House: Elements of a New Architecture.* (New York: Princeton Architectural Press, 2008), 142.

[199] Stephen Kieran and James Timberlake. "8.1 Deconstructed diagram of KieranTimberlake's Living Homes prototype." *Loblolly House: Elements of a New Architecture.* (New York: Princeton Architectural Press, 2008), 145.

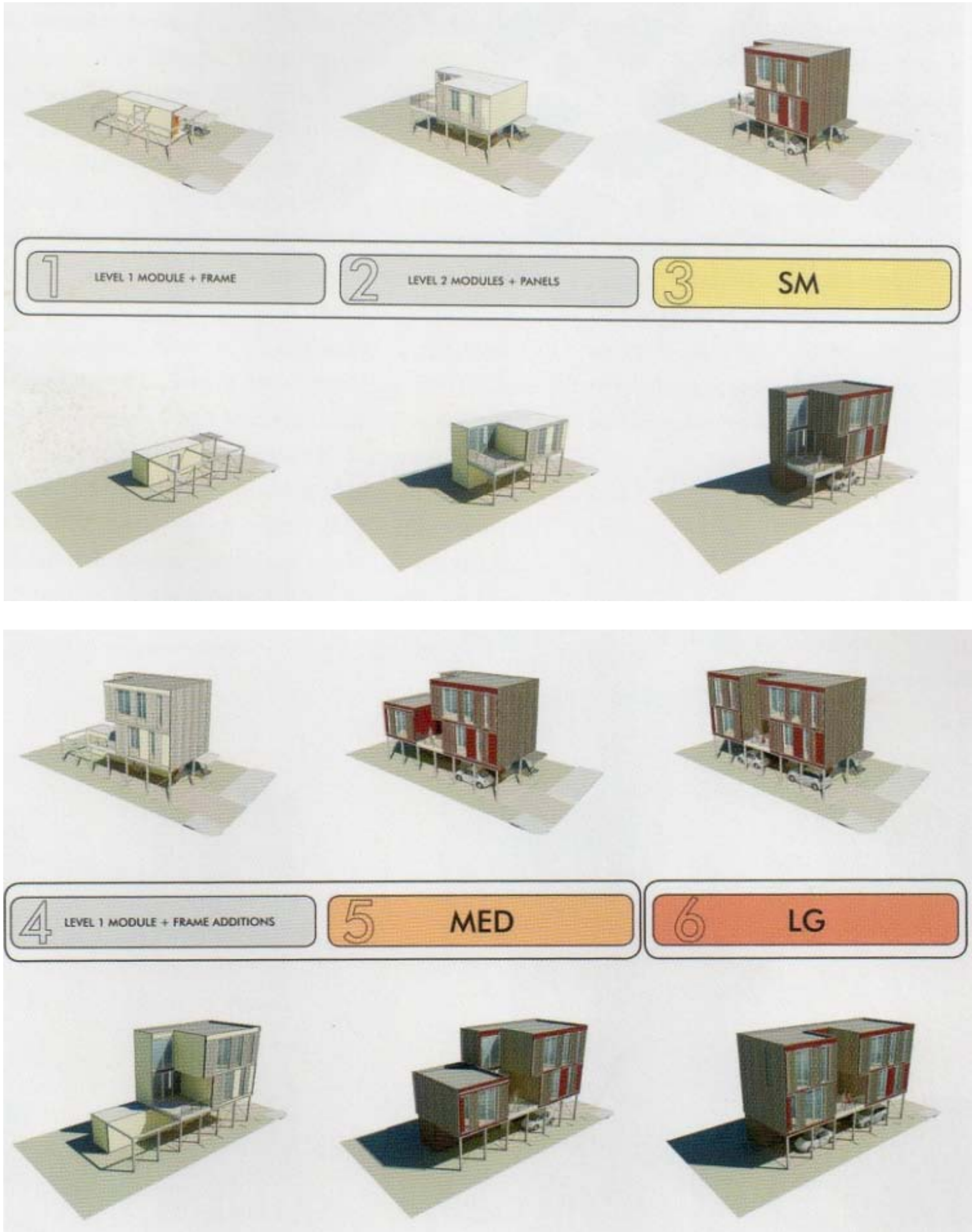

Image 41. Size variants and configurations of KieranTimberlake's LivingHomes Prototype[200]

[200] Ibid, 146-147.

Cellophane House

The Cellophane House is a 1,800 square foot case study house designed by Kieran Timberlake Associates for the Museum of Modern Art's 2008 *Home Delivery* exhibition. According to the firm, the Cellophane House "advances several aspects of the Loblolly House agenda: speed of on-site assembly, design for full disassembly, and a holistic approach to the life cycles of materials (using recycled and recyclable sources), as well as further development of the high-performance building skin first articulated in [their] SmartWrap Pavilion."[201] The Cellophane house also increased off-site assembly so that their project schedule for on-site assembly was reduced from six weeks down to one week. Generally this meant this project involved more 'spatial blocks' or modules versus 'panels'. The structure of the building was comprised of an aluminum frame while most of the floor panels, wall panels, and stairs were made of polyethylene terephthalate (PET) plastic.[202] The Cellophane house can be applied to a multifamily scenario as well. As Kieran and Timberlake show in their renderings, the house can be either a standalone building or combined in an urban setting to form townhouses.

Key Ideas: *Material Lifetime Consideration, Panelization, Prefabricated Kitchen/Bath Modules, Support + Infill, Design for Disassembly*

[201] Stephen Kieran and James Timberlake. *The Loblolly House: Elements of a New Architecture."* (New York: Princeton Architectural Press, 2008), 143.
[202] Ibid, 143-144.

1. Rendering of a multi-family complex in an urban setting.
2. Rendering of single-family home in a rural setting.
3. On-site assembly diagram

Image 42. Cellophane House Renderings & Concepts[203]

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[203] Stephen Kieran and James Timberlake. *Loblolly House: Elements of a New Architecture.* (New York: Princeton Architectural Press, 2008), 152-154.

2.5 Conclusion: A Method, not A Product

It is evident that Honolulu's current methods of providing housing that is affordable to its residents are both unsustainable and uneconomical, especially when analyzed from the standpoint of construction costs. In Part 1, we studied the various costs associated with housing including initial and long-term costs. Architects have little ability to control the cost of land, increase the availability of funding sources, or increase Hawaii's income levels to meet median home prices in order to make housing more affordable for Hawaii's population. What they have the ability to do is influence the cost of a building through its initial design and throughout its life span. From this, we determined that urban infill development in Honolulu was a good solution to address a key issue in Honolulu which was the cost (and availability) of developable land on Oahu, and the cost of site work, roadways, and infrastructure needed for housing development.

In Part 2, we looked at three experimentations in housing that emerged during the 20th Century and identified the key ideas, strengths and weaknesses of each one as it applies to urban housing design. From this study, it is evident that some of principles of Prefabrication, Flexible Housing, and Lifecycle Building Considerations overlap while others fight each other. The diagrams below attempt to illustrate the overlapping considerations and design elements that are fundamental between the three topics discussed in Part 2. Although there is no direct connection (with the exception of standardization) between all three subjects, there are several overlapping arguments between at least two of the three subjects.

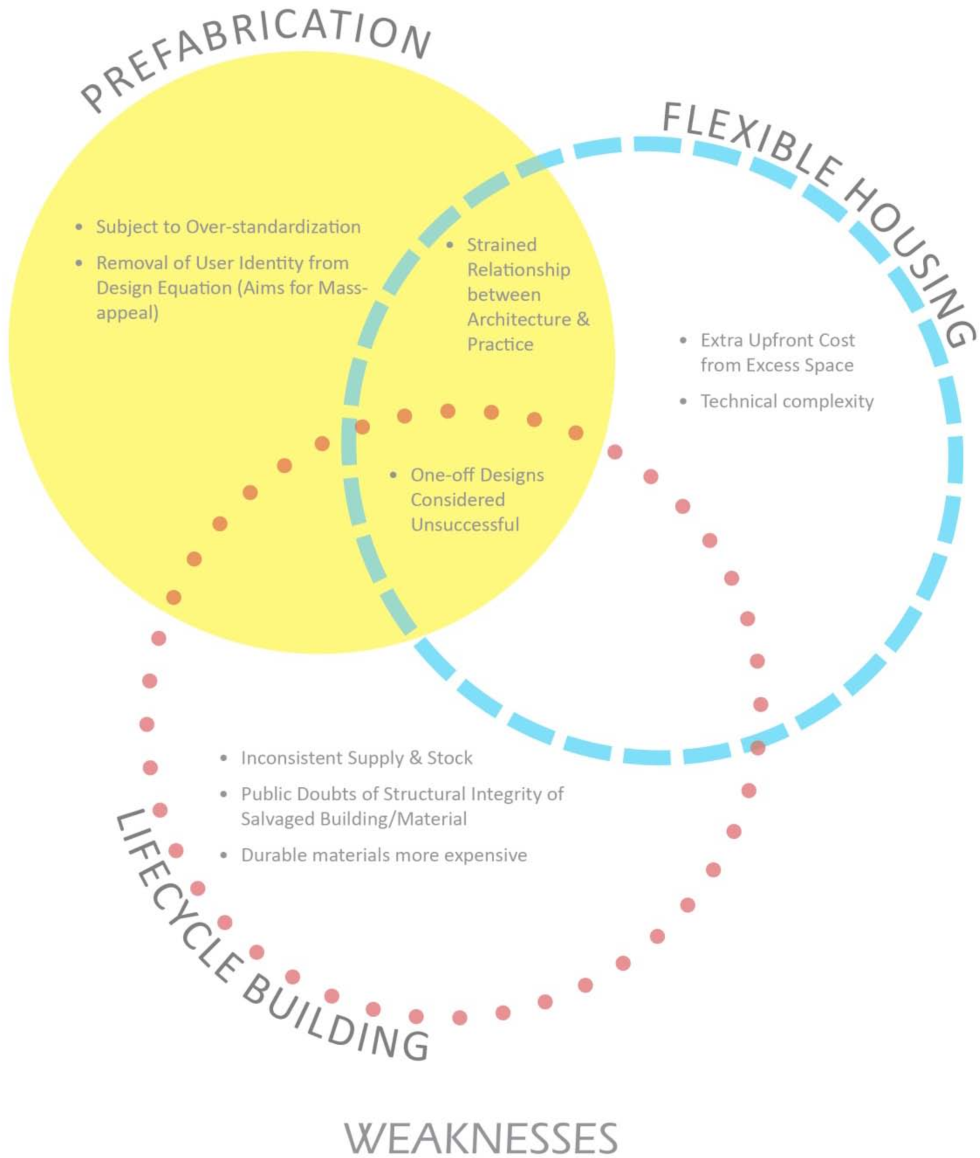

Image 43. Relationship Diagram of Weaknesses[204]

In all cases, the cause of failure to translate architect-designed homes for the masses is what Colin Davies, Tatjana Schneider and Jeremy Till refer to as the "one-off" design that essentially distinguishes a mere building from 'architecture.' In both prefabrication and flexible housing, failures of each movement stemmed primarily from the architects' fixation on developing the perfect "system." They were more interested in designing the technological components of the home rather than considering how the general public would accept or use the home. In the prefabrication movement, this involved developing the perfect factory-produced module or the perfect connectors for a designed kit-of-parts. In the flexible housing movement, this fixation

[204] Image by Author.

similarly came in the form of perfecting the perfect moving or sliding wall system or fold-up furniture.

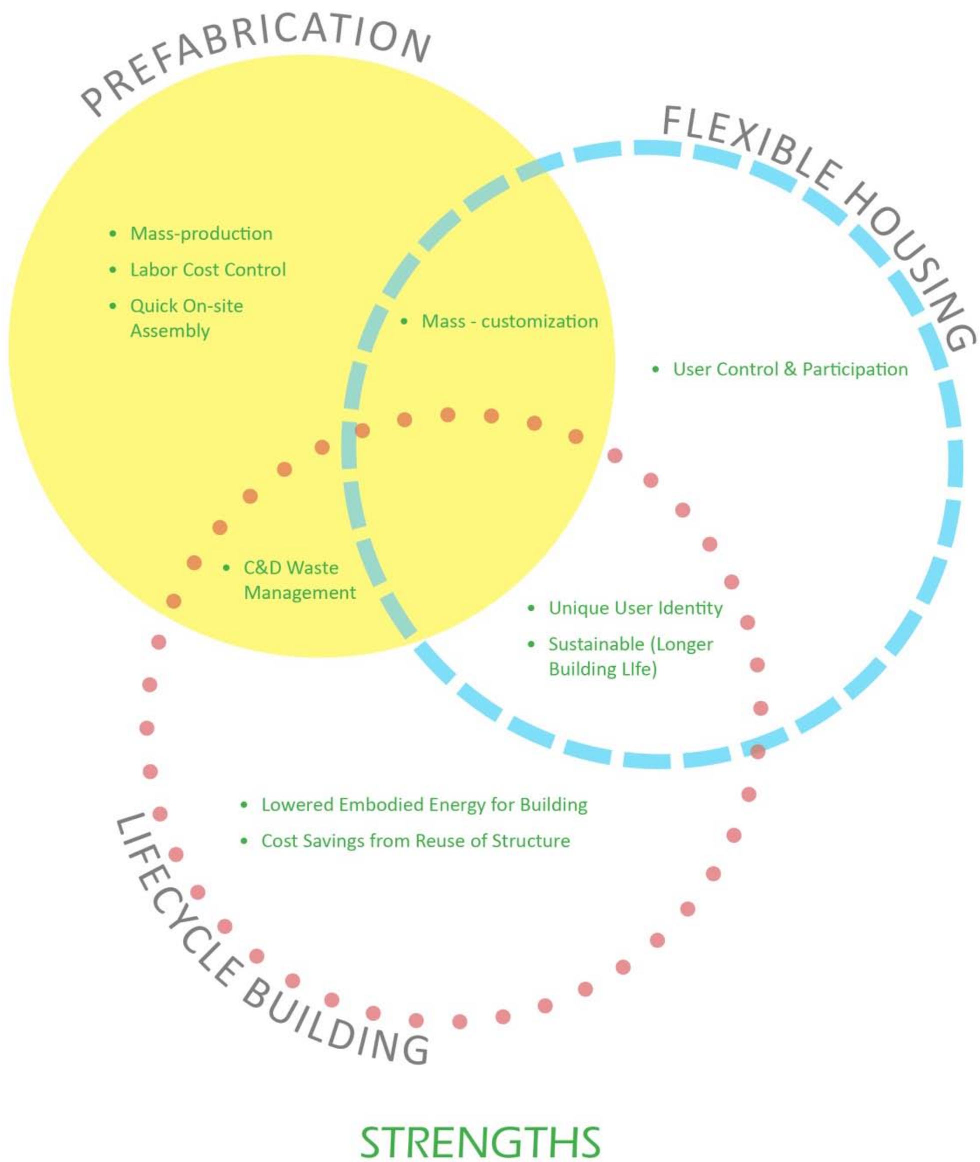

Image 44. Relationship Diagram of Strengths[205]

In a comparison of the strengths of each movement, we find that there is no shared strength amongst the three different topics. This doesn't mean that they are completely unrelated topics however. It may simply mean that strengths of one movement can balance out weaknesses in another. Flexible housing allows for user participation for multi-family housing design, an area that was lacking in the prefabrication movement. Prefabrication and building and material reuse help provide cost savings to balance out the extra expenditures that flexible housing can incur

[205] Image by Author.

with its request for excess space or wider circulation. As shown in the next diagram, there are several design elements encouraged by each movement that are shared amongst others.

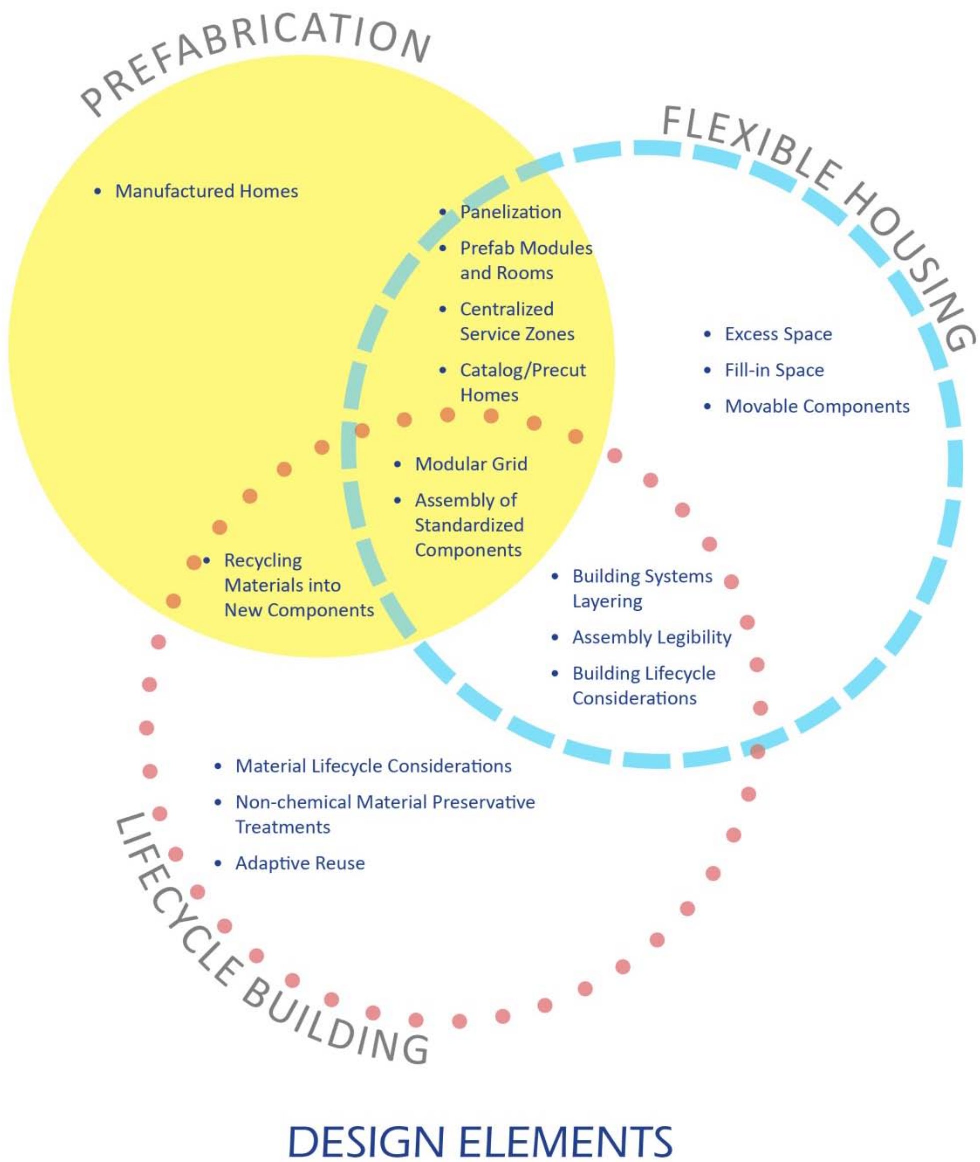

Image 45. Relationship Diagram of Design Elements[206]

The fact that there are several overlapping design elements shared by all three topic (both directly and indirectly) suggest that some sort of hybrid approach is a more appropriate solution than adhering to one approach or another in order to find that balance of standardization and individual expression needed for successful housing.

[206] Image by Author.

The Precedent Studies described in Section 2.4, standardization was achieved through the configuration of a set of prefabricated elements, custom-designed or otherwise. Beginning with Wright's Usonians, these studies show a progression of a practical and adaptable method of providing a level of customization in housing design based on the concept of reconfiguring standardized components. There are significant lessons learned from these precedent studies including construction approaches toward balancing prefabricated elements, flexible housing design principles, and even considerations for material life cycles.

Prefabrication can provide efficiency in materials and labor while flexibility provides means of user interaction to avoid the obsolescence that is ultimately built into any product (including housing). It is difficult to predict how people in general will live and what types of homes they will want to live in. Housing developers are essentially trying to anticipate the future and provide a product to meet future projections. Unfortunately, housing, like all other products, in a fixed form, will inevitably become obsolete in some way. Human needs do not remain constant throughout their lifetimes so why are the spaces they live in designed to be that way?

Reuse of buildings and their materials are an overlooked but nonetheless important consideration when creating sustainable built environments and reducing construction costs for housing projects, particularly in Hawaii where we have little to no local raw material resources. Originally, this project hoped to encourage the growth of a re-use industry in Hawaii by designing buildings for deconstruction (at least in part) to provide high quality material sources while allowing for flexible housing solutions for its residents. Reuse, if handled well, can be a much preferable alternative to recycling for Hawaii since it doesn't involve remanufacturing of waste material into new products which has huge negative environmental impacts.

Unfortunately with limited local resources for recycled and reusable building materials, simply specifying recycled and reusable materials into new buildings does little to nothing to control initial building costs. Unlike the works of the KieranTimberlake Architects and other designers that encourage DfD principles, Hawaii does not yet have the waste management industry support to be self-sufficient a way that would be cost effective. What distinguishes this project from these precedents is the added component of adaptive reuse that plays a major factor in terms of place-making. While adding adaptive reuse into the design equation risks the potential of the "one-off" design Davies, Scheider and Till warn against, the reuse of a building (and/or materials) further grounds a project into the history of its community solidifying its appropriateness to site and bringing the project back into the realm of architecture.

The following section outlines a set of design guidelines for an adaptive reuse project that employs elements of prefabrication, flexible design, and lifecycle building considerations. These guidelines serve as a summary of best practices based on the research conducted in Section 2.0.

Project Design Guidelines

The following section contains guidelines for such an approach to housing including desirable characteristics for buildings with high reuse potential, site selection, building design, unit design, and material considerations.

Adaptive Reuse Site Selection Guidelines

Site selection of an adaptive reuse project can have a major impact on the ultimate outcome of the project. As mentioned in Section 1, land costs are one of the major culprits affecting housing affordability in Hawaii. However, other factors of the project site can also cause a significant cost impact such as inadequate infrastructure and lengthy entitlement processes. Furthermore, the type of building slated for adaptive reuse would ideally be constructed in a manner that is can be renovated and/or adapted with minimal structural intervention. Selecting a building site for adaptive reuse should follow the following criteria in order to minimize cost and maximize flexibility:

- Buildings located in urban settings help reduce costs in terms of utilizing existing roadways, infrastructure, and civil support (e.g. schools, police stations, etc.).
- Urban lots zoned for mixed-use developments are also ideal for this type of project because the zoning ordinance or development rules allow for changes in use with fewer complications.
- Buildings with significant historic value or architecturally historic value generally complicate the amount of design experimentation allowed, especially on the exterior of a building. Improving a historically insignificant building can allow for a project that sensitively improves the neighborhood creating less neighborhood and public opposition.
- A building with a frame structure offers the maximum amount of flexibility because its structure is independent of the uses the building houses.
- Buildings with high ceilings are ideal. Not only are they aesthetically desirable, they provide the potential to divide the dwelling into two levels, create a loft/mezzanine, or simply provide more space to layer service systems (electrical, mechanical, plumbing, etc.)
- Ideally, the structure of selected building would be constructed of a durable nature such as concrete (ideal) or steel which decreases the chance that the structure integrity has been compromised by corrosion, termites, etc.
- Existing structures that have already been designed for heavy loads (like those designed for industrial warehouses) minimize the need for additional and costly structural interventions to accommodate new uses. In some cases, such structures may provide additional parking to meet increased off-site parking requirements imposed by zoning ordinances for changes in occupancy use or can accommodate vertical additions.
- If possible, avoid buildings whose service systems are encased in, bored through, or otherwise integrated with the structural system. Service systems that are independent

of structural systems allow for easier removal or replacement of outdated, abandoned, or insufficient parts (or whole systems).

Overall Building Design Guidelines

Once the building slated for adaptive reuse has been selected, a preliminary evaluation needs to be conducted to determine what can be kept, what needs to be upgraded or replaced, and a thorough zoning and code analysis study needs to be conducted in order to formulate the program based on existing conditions and assumptions of what can be kept.

One of the major variables in expenses for adaptive reuse is bringing the existing building and its systems up to code and accessibility standards. Depending on how old the building is and its previous occupancy, a significant amount of money could be spent on upgrading sewer and water lines, repairs, etc.

Once the level of design has been determined, the following design guidelines can be applied or considered for the overall building design:

- The kitchen and baths are often the most permanent elements in a plan and their locations should be considered first in the design process – at the very least where the locations of the service core should be located. There is no additional cost for this method if done during the planning stages of a new project.[207]
- Keep building systems separate from structural framework.
- Allow for 'fill-in' spaces such as larger corridors that can accommodate seating, mail areas, extra storage, etc. This most likely will add extra costs, however.
- Services should be collected in vertical stacks and the main rooms that receive these services should be grouped around these stacks. These stacks should also be available for future upgrading.

Dwelling Unit Design Guidelines

The goal for the design of the dwelling units is to maximize both pre-occupancy and post-occupancy adaptability while minimizing costs. Here is where the use of flexible design tactics should be strategized. As mentioned in the flexible housing section of this paper, a combination of determinate and indeteminate design tactics should be utilized.

In order to control costs, a certain amount of prefabrication or prefabricated elements should be utilized. At the very least, a method of standardization should be employed whether it be large scale entirely prefabricated dwelling unit modules, prefabricated kitchens/baths, some form of panelized construction or precut/modularized building materials.

- For quality control, it is best to do as much assemblage as possible in a factory. There is more space, better working conditions, more equipment, and closer supervision.[208]

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[207] Tatjana Schneider and Jeremy Till, *Flexible Housing.* (London: Elsevier, 2007), 197.
[208] Colin Davies. *The Prefabricated Home.* (London: Reaktion Books, 2005), 150.

- An assembly of smaller standardized pieces offers the most flexibility and is more easily transportable to a site. The smaller the standardized component, the more flexibility is inherent (precut members are the most flexible).
- Avoid fixating on attaining the perfect building system and instead focus on the space-making and aesthetic aspects of the building using standard construction methods.
- Designed components should be interchangeable with existing building systems (or components) in order to be applicable to various circumstances. "New technologies designed in isolation on the drawing board are very unlikely to be successful. Technologies have to be developed, not designed, and you need a factory to develop them in…it is usually safer and cheaper to adapt an old technology."[209]
- **Consolidating service systems** to a single, centralized passageway (or chase) efficiently utilizes space, simplifies access to utilities, and allows for more flexibility (in the preoccupancy stage) as piping, ducts, etc. can branch of from the main lines.[210]
- **Clear spans** across the width of an individual unit provide the maximum amount of flexibility within that unit as interior partition walls become non-load bearing and therefore easy to move around.
- **Movable components** such as sliding walls, folding furniture, etc. should be used as a means toward achieving flexibility in spatial use and not be the defining element of the design.
    - Modular wall elements may provide a kit of parts such as doors, wall panels, and framed openings. More successful projects employ a smaller number of elements.
- **Partition walls** should be non-load bearing and not contain any services when possible.
- Wall and/or floor finishes should continue past or under any removable partitions or cabinetry.
- Consider including knock-out panels in pre-framed openings to allow for expansion or connection of adjacent rooms without any major structural work.
- Provide 'instruction manuals' for dwelling units so that new residents can understand how they are able to modify their units if they were not involved in the original design process. [211]

Material Reuse Guidelines

When applicable, reuse what materials are available on site first. Secondly, look at materials from local reuse resources such as reuse warehouses, other project demolition sites. For higher quality salvaged material, one could look at companies that salvage reclaimed wood but these could be more expensive since often times the wood grade is higher, the product is acquired from non-local sites (usually the mainland U.S. and South East Asia) and the product cost includes refinishing.

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[209] Colin Davies. *The Prefabricated Home.* (London: Reaktion Books, 2005), 203.
[210] Avi Friedman, *The Adaptable House.* (New York: McGraw-Hill, 2002), 172-173.
[211] Avi Friedman, *The Adaptable House.* (New York: McGraw-Hill, 2002),173.

For the most part, the use of salvaged material that is visually distressed and weathered materials are best to be used in decorative applications in urban multi-family residences. Although the use of salvaged material can add a lot of character and charisma to a building, it is unlikely that the residents will appreciate the fact that their dwelling unit is built using second hand materials given general preconceived stigmas held against salvaged material (even if it is structurally sound). Probably the best use of salvaged material is as decorative treatment in amenities areas or in the residential corridors to break up the long spaces (e.g. applying salvaged material at the ends of corridors, within unit entry nooks, or incorporating them into signage).

Also, given the issues that it is difficult to acquire large amounts of salvaged material at a time, limiting its application throughout the building can be sensible.

- The use of uniformly-sized members yields more usable material when the building is deconstructed and its material reused.
- Use bolted connections or other mechanical fasteners rather than welding, adhesives, or otherwise permanent connections.
- When costs permit, use solid wood products as you can repair and refinish scratches and dents much easier than using an engineered wood or laminated product.
- Avoid drilling and threading wiring and plumbing through the building structure (particularly if using wood studs). Instead, layer systems independent of structure (when space permits) or use products that allow systems to be threaded through without damage to the structural member (e.g. light gauge metal framing studs, open web joists, raceways, etc.).
- Avoid materials that have been chemically treated since they can be toxic to both dwelling users and workers involved in re-milling or construction.
- Avoid wet finishes such as plaster or stucco as they are non-reusable or recyclable. Or incorporate them into a panel system so that the entire finished panel can be reused.
- Label all members with material grades (and ideally, use the same grade). This will help inform deconstruction contractors and material reuse warehouses of their stock they receive from deconstructed buildings and maintain a uniform stock. It also gives structural engineers a better understanding of what the load capacities are for salvaged materials that will be used for new projects.

3.0 DESIGN

The design portion of this project is the adaptive reuse of an existing, under-utilized structure in urban Honolulu into multi-family housing that is affordable to Honolulu residents. The design intends to utilize a combination of design strategies for flexible housing, prefabrication, and lifecycle building considerations in order to provide a solution for quality, long-term housing that is affordable. Cost parameters shall be identified to determine the feasibility of this project in terms of affordability in Honolulu.

3.1 Project Site Information: Kaka‘ako Commerce Center

The project site is the current Kaka‘ako Commerce Center, a 6-story industrial warehouse and office building located in Kaka‘ako, a special development district that is regulated by the State of Hawaii-appointed Hawaii Community Development Authority (HCDA). The building is a reinforced concrete frame, with concrete load bearing walls on the Ewa and Diamond Head facades with CMU infill walls along the Mauka and Makai facades and metal stud partition walls on the interior.

Image 46. Project Site: Kaka‘ako Commerce Center[212]

[212] "Kakaako Commerce Center." Loopnet.com. <http://www.loopnet.com/Listing/15708260/875-Waimanu-Street-Honolulu-HI/> (Accessed May 7, 2012).

Table 7. Property Information Summary[213]

KAKAAKO COMMERCE CENTER	
Address	875 Waimanu Street Honolulu, Hawaii 96813
TMK	2-1-049-045
Land Area	54,848 SF
Land Value	$8,309,900
Building Area	234,100 SF
Building Value	$7,761,600
Current Use	Industrial/Warehouse (Floors 1-5) Office (Floor 6)
Owner Representative	Red Tail Acquisitions, LLC
Year Built	1971
Neighborhood	Central Kaka'ako (CK)
Zoning	Kaka'ako Community Development District (Managed by HCDA) – Mauka Area Plan

Site Context

Kaka' ako has been an area of high redevelopment interest because of its underutilization and its central location amongst several major special design districts. The primary concept for Kaka' ako master plan is the 'urban village' – a self-sustainable community where mixed-use development is encouraged so people are able to 'live, work, shop and recreate' in their neighborhood.[214] This preference for mixed-use development in this area makes adaptable reuse much easier from a zoning and land use standpoint, since its requirements are a little more flexible than those outlined by the City and County of Honolulu Land Use Ordinances, making it a preferable site for the project proposed in this document.

[213] City and County of Honolulu Department of Planning and Permitting. "875 Waimanu," *Property Information.* http://gis.hicentral.com/pubwebsite/TMKDetails.aspx?tmk=21049045&lyrLst=0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|14|0|16|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|lblsaerial2008&unit=0000&address=875%20WAIMANU%20ST. (Accessed January 20, 2012)

[214] Hawaii Community Development Authority. "Mauka Plan Principles." *Kaka'ako Community Development District – Mauka Area Plan.* September 2011, 8.

Image 47. View of Kaka'ako from Kaka'ako Commerce Center Roof (Kawaiahao Street)[215]

Some of the hurdles faced by the adaptive reuse of the project site are directly tied to its location in the Central Kaka' ako (CK) neighborhood zone, an area composed primarily of small, individually owned properties. The primary uses in this area are services businesses, repair shops, and production facilities most of which are industrial in character. HCDA has identified significant functionality problems in Central Kaka'ako including inadequacy in parking, storm drainage and sidewalks. HCDA's strategy for this area is to 'support the viability of small business use while allowing for potential future re-use of small properties in this neighborhood through selective improvements to streets and parking.'[216] From a cost perspective, this means that currently, there is inadequate infrastructure in this area for housing and that area improvement or upgrading costs may be required as a result of increased demands on utilities, parking, and thoroughfares.

[215] Image by Author.

[216] Hawaii Community Development Authority. *Kaka'ako Community Design District: Mauka Area Plan.* September 2011, 14.

Vehicular Traffic Analysis

The roads surrounding the project site and its block are primarily "streets" and "service streets" indicating that not much traffic is expected in these areas. According to HCDA, "streets" are walkable, low-speed (25 mph) thoroughfares that provide connectivity (both vehicular and pedestrian) between neighborhoods, commercial districts, and other local streets. "Service streets", on the other hand, have limited pedestrian access and primarily provide vehicular access to lots. They typically have two travel lanes and one parking/loading lane. Because of the small parcels and existing right-of-way conditions in the Central Kakaʻako neighborhood zone, the pedestrian realm does not require front yard space or trees.

The project site is also located near three major thoroughfares – Kapiolani Boulevard, Ward Avenue, and Cooke Street.

Table 8. Kakaʻako Roads [217]

ROAD NAME	ROAD TYPE	SPECIAL FEATURES	RIGHT OF WAY (ROW)
Waimanu	Service Street		40'
Kawaiahao	Street		50'
Kamani	Service Street	Possible Street Closure	40'
Cooke	Promenade Street	4 Travel Lanes	60'
Drier	Service Street		40'

[217] Ibid, Table 7-1: Kakaʻako Mauka Area Roads, 35 -36.

Thoroughfare Plan Requirements & Compliance

The HCDA's Mauka Area Rules Section 15-217-39 (B)(3) states that developments and improvements to existing buildings must comply with the Mauka Area Rules Thoroughfare Plan if the value of changes or renovations are equal or greater than 50% of the replacement value of the existing improvements.[218]

This rule could create significant costs to the project since the value of changes are almost guaranteed to exceed 50% of the existing improvements' replacement value. Only two roads have direct impact on the site development of the project site – Waimanu Street and Kawaiahao Street. Waimanu is considered a "service street" with limited pedestrian access. Of particular concern is Kawaiahao Street which is considered a "street" which is meant to serve both vehicular and pedestrian access. Currently, a 10'-0" setback is designated along the Kawaiahao Street property line but no sidewalks have yet been constructed along any portion of this street.

Pedestrian Access

Currently, the project site and its immediate surroundings are void of any pedestrian sidewalks. Because the entire renovations are expected to exceed the 50% replacement value limit set by the Mauka Area Rules, infrastructure improvements will be required to be included in the project scope. The Mauka Area Rules designate three functioning areas within the designated pedestrian zone: (1) furnishing area, (2) pedestrian throughway, and (3) private frontage.

Because Waimanu Street is considered a service street, it does not require the furnishing area or private frontage area – only a minimum 6'-0" wide pedestrian throughway. Kawaiahao Street on the other hand is considered a "street" and therefore requires a minimum 2'-0" wide furnishing area, a minimum 6'-0" wide pedestrian throughway, and a minimum 2'-0" wide private frontage area.[219]

A 10'-0" sidewalk setback exists on the Kawaiahao Street property frontage accommodates the minimum required dimensions of pedestrian zone described above. However, this area has not been improved to meet the design standards described in the Mauka Area Plan.

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[218] State of Hawaii, Department of Business, Economic Development and Tourism, *Repeal of Chapter 15-22 and Adoption of Chapter 15-217 Hawaii Administrative Rules.* (Honolulu, 2011), Sec.15-217-39 (B)(3)

[219] Hawaii Community Development Authority. "Figure PZ.5. Pedestrian Zone Treatment, Central Kakaako (CK) Zone." *Mauka Area Plan.* (Honolulu, 2011), 54.

10'-0" Sidewalk Setback

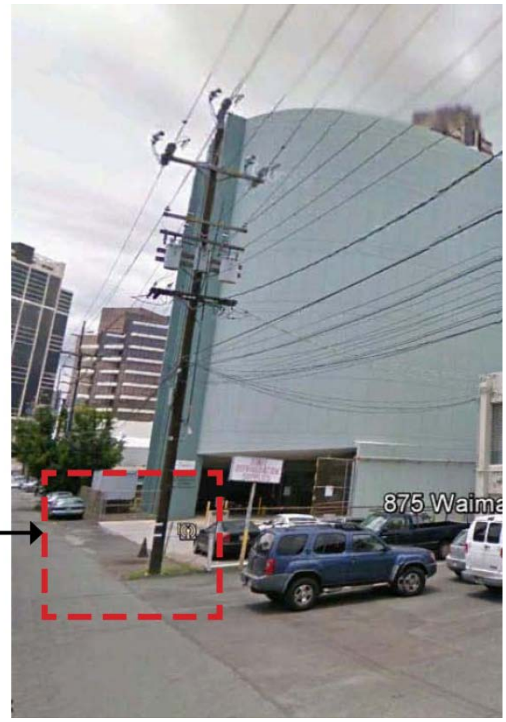


Image 48. Kawaiahao Street Setback for Pedestrian Zone[220]

Access to Public Transportation

The project site is in an almost ideal location in terms of access to public transportation – both existing and future modes. A major bus stop is located on the corner of Ward Avenue and Kapiolani Boulevard, about two blocks away from the project site. The site is also within walking distance of two bus stops along Queen Street. The site is also within walking distance of the site for the future rail station that is to service Kaka‘ako.

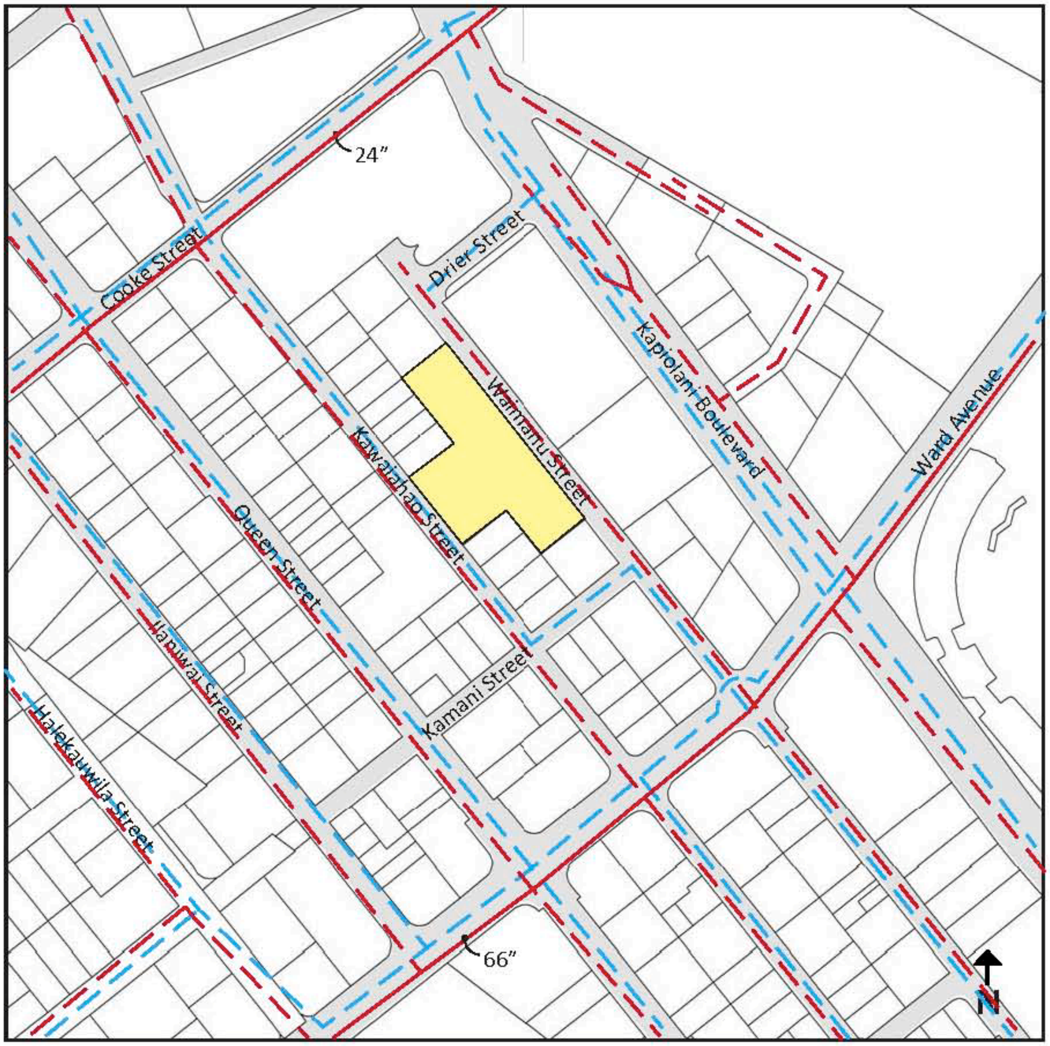
[220] Base image generated from Google Earth Street View. "875 Waimanu Street, Honolulu, Hawaii."

Upgrading of Utilities

The Mauka Area Plan proposes upgrading several infrastructure elements to accommodate anticipated increased usage over time. Although the Mauka Area Plan and its Rules permit residential mixed use within the Central Kakaʻako neighborhood zone, it does not have significant plans to upgrade any of the sewer or water systems in the neighborhood to accommodate its use at this point. Waimanu Street is subject to receive new storm water drain lines and drain inlets/catch basins. The closest upsized sewer line is along Ward Avenue.

If this project were to move ahead now, the developer would likely be responsible for the proposed infrastructure improvements along Waimanu and Kawaiahao Streets since residential use has a much higher demand on sewer lines than industrial use. Although there are residential mixed use developments in various areas in the neighborhood, these properties likely connect to the recently upgraded sewer lines along Kapiolani Boulevard or Ward Avenue.

Image 49. Mauka Area Plan Proposed Sanitary Sewer and Water Systems[221]



DRAWING KEY

Project Site

Existing Sewerline to Remain

Upsized Sewerline

Existing Waterline to Remain

Upsized Waterline

The above diagram shows the Mauka Area Plan's proposals for upsizing of the Kakaako Mauka Area Sanitary Sewer System and Water System. No infrastructural upgrades are planned along Kawaiahao Street or Waimanu Street.

Sewer upsizing is planned for Ward Avenue which this project may be able to connect to.

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[221] Adapted from Hawaii Community Development Authority, "Figure 13.2 – Sanitary Sewer System" and "Figure 13.3 – Water System", *Kaka'ako Community Development District Mauka Area Plan.* September 2011, 61-62.

Zoning Regulations

The project site is somewhat appropriate to the flexible nature of this design project. Kakaʻako is currently a high-interest area for redevelopment and is regulated by the HCDA's Mauka Area Plan and Mauka Area Rules rather than the City and County of Honolulu's zoning regulations. The benefit is that the Mauka Area Plan for Kakaʻako heavily encourages mixed use development. This frees up a lot of the typical zoning and land use regulations and restrictions adaptive reuse projects might face in other parts of the island. Although the immediate neighborhood surrounding the project site is primarily industrial in nature, the Mauka Area plan allows a variety of uses for the area including residential mixed-use, administrative offices, automotive services, etc.[222]

However, because the Mauka Area Plan was just implemented last year, many of the proposed improvements to infrastructure to support residential use have yet to be implemented. A few of the major issues and potential roadblocks with the project site are the lack of inadequate sewer lines, roadways, sidewalks, and parking in the immediate neighborhood. This can limit the density of any new project unless the developer is willing to take on expenses of upgrading the infrastructure to meet the new demands. The Mauka Area Plan states that the Central Kakaʻako neighborhood zone in which the project is located in has a maximum FAR of 3.5. However, because of the current lack of infrastructure in the area, the Mauka Area Rules currently limit the maximum FAR to 1.5 until the HCDA director has determined that the infrastructure of this zone has been sufficiently upgraded. When that happens, the maximum FAR will be raised to 3.5.[223]

[222] Hawaii Community Development Authority. "Figure 1.9 Land Use." *Kakaʻako Community Development District Mauka Area Plan - Figures.* September 2011, 13.

[223] State of Hawaii, Department of Business, Economic Development and Tourism, *Repeal of Chapter 15-22 and Adoption of Chapter 15-217 Hawaii Administrative Rules.* (Honolulu, 2011), ch. 217. Sec. 57, 217-53.

Table 9. Permitted Land Uses in Central Kaka'ako Neighborhood Zone[224]

LAND USE	PERMITTED	NOT PERMITTED
Residential	Multi-family, Second Unit, Group Home, Home Occupation	Single Family
Office	Administrative	
Goods & Services	Alcohol Sales, Artisan/Craft Production, Dance-Nightclub, Indoor Recreation, Live-Work, Outdoor Recreation, Personal Services, Recycling Collection Facilities, Restaurants & Bars, Retail Sales	
Civic	Group Assembly, Cultural Facilities, Park & Recreation, Public Building, Religious Facility, Theater	Conference Center
Automotive	Automobile Repair, Gas Station, Auto Rental/Sales, Parking Facility	
Civil Support	Consulates, Medical & Dental Clinic	Hospital
Educational	Day Care Center, Day Care Home, Educational Facilities, Vocational School	
Industrial	Laboratory Facility, Light Industrial, Media Production, Printing and Publishing, Warehousing	

Housing Requirements

Kaka'ako's housing development program is geared toward reserving a certain amount of housing to be affordable to 'workforce' or 'gap-group' buyers who earn between 100-140% of Honolulu's area median income (AMI). The Mauka Area Plan proposes a 'reserved housing rule' that requires residential developments on lots greater than 20,000 SF of to develop and construct 20% of the residential floor area as units to be sold or rented to households earning no more than 140% of Hawaii's AMI.[225] These units are referred to by HCDA as 'Reserved Housing'.

In an ideal situation, reserved housing units would be intermixed with market rate housing, but according to the HCDA Mauka Area Rules, the reserved housing units do not necessarily have to

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224 Adapted from Hawaii Community Development Authority. "Figure 1.9 Land Use." *Mauka Area Plan.* (Honolulu, 2011), 54.

225 Hawaii Community Development Authority, Kaka'ako Community Development District. *Mauka Area Plan.* (Honolulu, 2011). Sec. 8.2, 44.

be located on the same site as the market rate units.[226] Because of the relative low density of this project, it would be financially unfeasible to develop a stand-alone residential mixed-use development. Instead, a more practical solution may be to develop all the units as Reserved Housing units to a developer who needs to meet the reserved housing requirements.

According to HUD's definition of housing affordability, households should pay no more than 30% of its annual median income toward housing. Households that pay more than this are considered to be cost-burdened – meaning that they are unable to afford the cost of other necessities such as food, transportation, and health care.[227]

The Department of Housing and Urban Development (HUD) has listed Honolulu's area median household income (AMI) at $81,600.[228] Applying the HUD definitions to the requirements set forth by the Kakaʻako Community Development District Mauka Area Rules, the targeted household incomes that qualify for the Reserved Housing requirement fall between $81,600-$114,240. Thirty percent of the higher end of this income bracket equals about $34,272 which is the maximum amount of money that this income group should spend on housing costs annually (or $2,856 monthly).

Table 10. Reserved Housing Income Limits

	RESERVED HOUSING INCOME LIMITS	ANNUAL HOUSING EXPENSE LIMIT (30% OF INCOME)	MONTHLY HOUSING EXPENSES
Honolulu Area Median Income (Base)	$81,600	$24,480	$2,040
Moderate Income Maximum (140% AMI)	$114,250	$34,272	$2,856
Low-Income (80% AMI)	$65,280	$19,584	$1,632

[226] Hawaii Community Development Authority. *Kakaʻako Community Development District Mauka Area Plan.* September 2011, 44-45.
[227] U.S. Department of Housing and Urban Development. "Community Planning & Development." *Affordable Housing.* http://www.hud.gov/offices/cpd/affordablehousing/ (Accessed 30 September 2010).
[228] U.S. Department of Housing and Urban Development. *FY 2011 Income Limits Briefing Material.* 1 June 2011. http://www.huduser.org/portal/datasets/il/il11/IncomeLimitsBriefingMaterial_FY11_v2.pdf (Accessed 26 January 2012).

Landscape & Recreation Space

Development projects that require development permits are required by the HCDA to provide 55 SF of recreation space per dwelling unit.[229]

Off-Street Parking Requirements

Because this project involves the conversion of an industrial warehouse building into a multi-family dwelling, additional parking is required. Currently, the building has 95 parking stalls, 15 of which are tandem stalls. Most of these stalls are located on the roof deck of the building and accessed by the circular car ramp along Kawaiahao Street, while others are located in the area near the loading dock on the ground floor, also located along Kawaiahao Street.

The HCDA's Mauka Area Rules state that "if there is a change in use which has a greater parking or loading requirement than the former use, additional parking and loading shall be required and shall not be less than the difference between the requirements for the former use and the proposed use."[230] The table below summarizes the off-street parking requirements as stated in the Mauka Area Rules for the Kaka'ako Community Development District for potential uses specific to this project site.

[229] State of Hawaii, Department of Business, Economic Development and Tourism, *Repeal of Chapter 15-22 and Adoption of Chapter 15-217 Hawaii Administrative Rules.* (Honolulu, 2011), ch. 217. sec. 56.
[230] Ibid, ch. 217. sec. 91(f)(2)(H).

Table 11. Summary of Mauka Area Rules' Off-Street Parking Requirements[231]

USE	OFF-STREET PARKING REQUIREMENT
Multi-Family Dwelling less than 600 SF	0.9 stall per unit
Multi-family Dwelling greater than 600 SF	1.25 stalls per unit
Commercial, Clinics, Administrative and all other uses	1 stall per 450 SF
Restaurants/Bars/Nightclubs	0.9 stall per 300 SF of eating/drinking area + 0.9 stall per 25 SF of dance floor area + 1 stall per 450 SF of kitchen/accessory use area
Industrial, media production, printing, publishing and warehousing (existing use)	1 stall per 900 SF

Currently, there are no off-street parking requirements for Central Kakaʻako neighborhood zone area.[232] However this project will still aim to meet the parking requirements as outlined by the HCDA for residential mixed use developments.

There is a total of 175 existing parking stalls located at various floors throughout the building. A considerable amount of the parking provided are tangent stalls and was counted as two stalls for this project. According to the HCDA, tandem stalls are permitted in parking facilities used for residential purposes when both spaces are used by a single dwelling.[233] The following table summarizes the amount of existing parking provided by floor level.

Table 12. Summary of Existing Off-Street Parking Stalls Per Floor

FLOOR	STALLS PROVIDED
1	17
2	10
3	12
4	10
5	4
6	0
Roof	122

Parking access to the building is preferred via an Alley Street. If unable to access from alley, parking access shall be from a parking access street.[234] Fifty percent of parking provided must be standard-sized parking spaces (8'-6"W x 18'-0"L); compact-sized parking space dimensions are 7'-6"W x 16'-0"L.

[231] Ibid, ch. 217. sec. 63.

[232] Ibid, ch. 217. sec. 63(e)(2), 217-63.

[233] Ibid, ch. 217, sec. 63 (i)(1), 217-65.

[234] Ibid, ch. 217. sec. 63.

Because there were no requirements for guest parking stalls mentioned in Mauka Plan or Rules, the project will therefore provide 1 guest parking stall per 10 dwelling units.

Mauka Area Rules allows for a decrease in parking requirement if parking is shared. However, for the purposes of this project no shared parking ratios will be factored in.

Bicycle Parking

Short term and long-term bicycle parking shall be provided. Bicycle parking shall also be provided within 400'-0" of the principle entrance of the building.[235]

Loading Requirements

The existing structure's previous industrial use required more loading areas than will be required for the proposed multi-family dwellings with the same floor area. According to the Mauka Area Rules' Loading Space Requirements, multiple-family dwellings with a floor area between 150,001-300,000 SF are required to provide only two loading zones while the buildings previous use would have required at least 3x that amount based on the current Mauka Area Rules.[236]

Nonconformities

Since this building was originally constructed almost 40 years prior to the implementation of the current Mauka Area Plan and Rules, parts of its structure does not conform to the current rules and regulations although it may have conformed to the rules and regulations in effect at the time of construction. Such nonconformities include exceeding the 65'-0" maximum building height for the neighborhood, not matching any of the allowable building types described in the Mauka Area Plan, and not meeting the 15% minimum open space requirement.

The Mauka Area Plan and Rules cover two types of nonconformities – Nonconforming Use and Nonconforming Structure. The change in use to Residential Mixed-Use is in compliance with the allowable uses for the Central Kakaʻako neighborhood zone. For nonconforming structures, the Mauka Area Rules allows the building to remain as nonconforming as long as the structure remains in good repair. However, if damaged (by any means, including renovations, alterations, etc.), the repair cost of the conforming structure cannot exceed 50% of the replacement cost in order to remain non-conforming.[237]

The parts of the building that needs to be upgraded are the off-street parking requirements and plumbing requirements. The conversion to residential use requires much more parking than is or has been required for commercial/office and industrial use. Residential use also demands heavier sewer and water usage since more plumbing fixtures are provided per unit than commercial and industrial uses.

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[235] Ibid, ch. 217, sec. 63 (m)(1-2), 217-68.
[236] Ibid, ch. 217. sec. 63 (l)(1), 217-66 – 217-67.
[237] Ibid, ch. 217, sec. 91, 217-94 – 217-96.

3.2 Existing Building Conditions

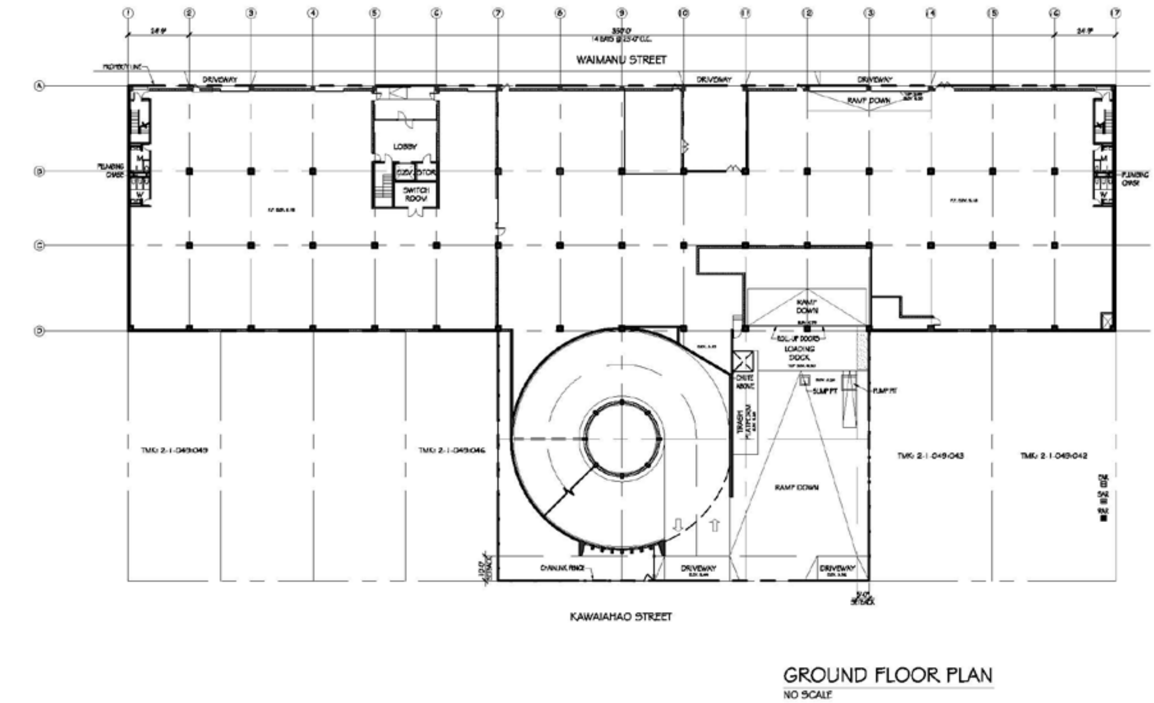

Image 50. Ground Floor Plan with Column Grid[238]

With no side or rear yard setbacks, the building was built right up to the property line along all sides except for the property line fronting Kawaiahao Street.

The Kakaʻako Commerce Center is a reinforced concrete frame structure with hollow concrete masonry unit infill walls along the Mauka and Makai facades. Hollow concrete masonry unit walls are also constructed around the lifting dock and container platforms along Waimanu Street. The Ewa and Diamond Head facades are a reinforced concrete walls as are the walls surrounding the stair and elevator cores. The rest of the walls that partition off the tenant spaces are 6" metal stud and gypsum board walls.

A "lifting dock" is situated in the structural bay between column line #10 and #11 on the ground floor. This lifting dock and adjacent container platforms on floors 2-4 are housed below a travelling crane installed on the 5th floor. Floor-to-floor heights are 15'-0".

[238] Image reproduced by author from drawings by Hsi, Hwei-Yang. "Waimanu St. Development for the Hawaii Corp," Architectural Drawings for Building Permit Application. October 14, 1969, A-2.

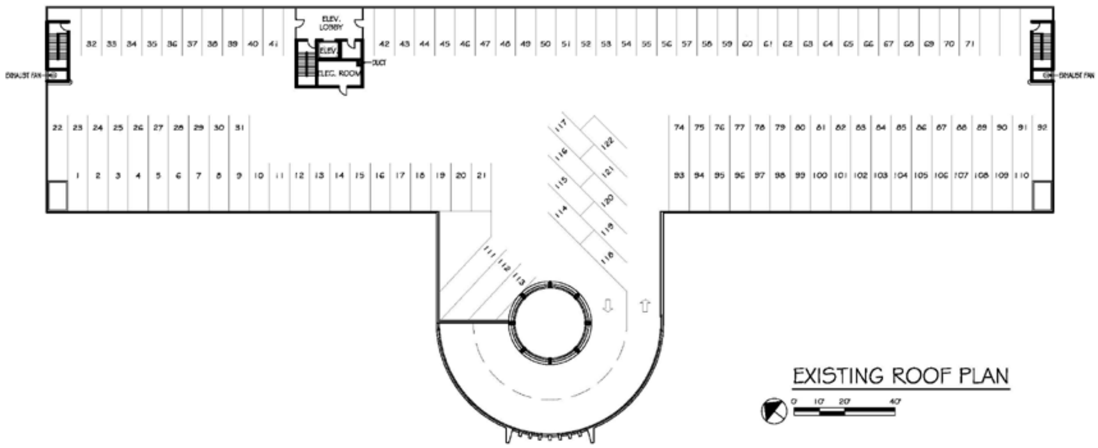

Image 51. Existing Roof Plan with Parking Layout[239]

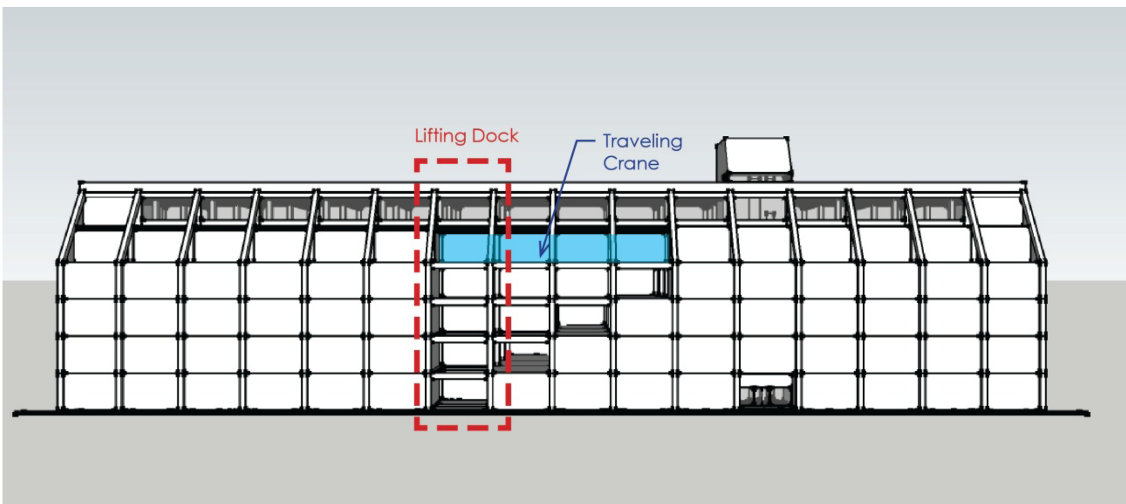

Image 52. Massing Model of Existing Building – Waimanu Street Elevation[240]

[239] Image reproduced by author from drawings by Hsi, Hwei-Yang. "Waimanu St. Development for the Hawaii Corp," Architectural Drawings for Building Permit Application. October 14, 1969, A-7, and from Google Maps Images for "875 Waimanu Street."

[240] Image by Author.

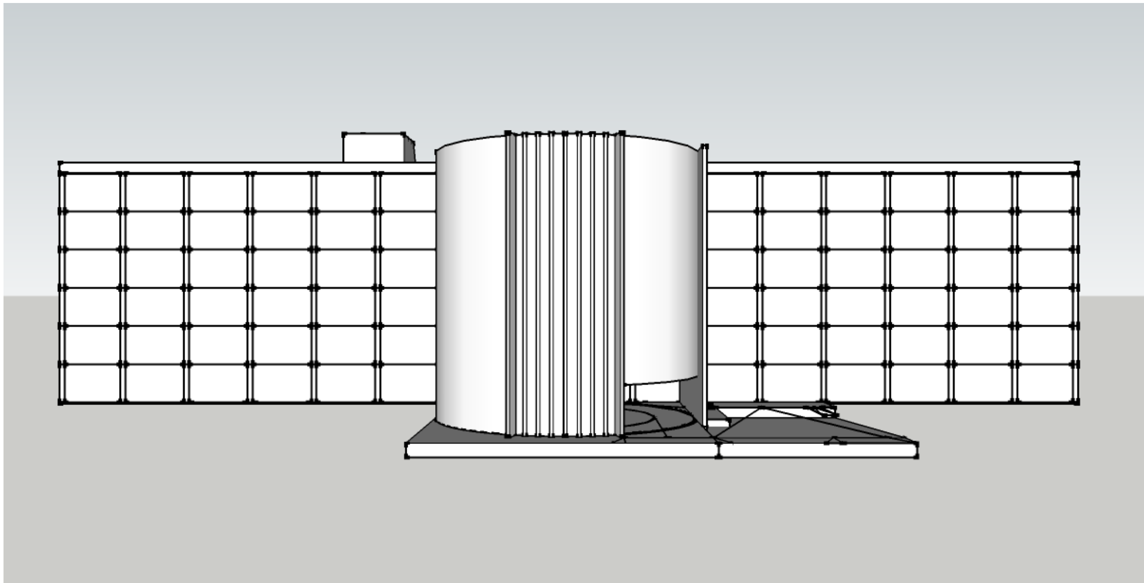

Image 53. Massing Model of Existing Building - Kawaiahao Street Elevation[241]

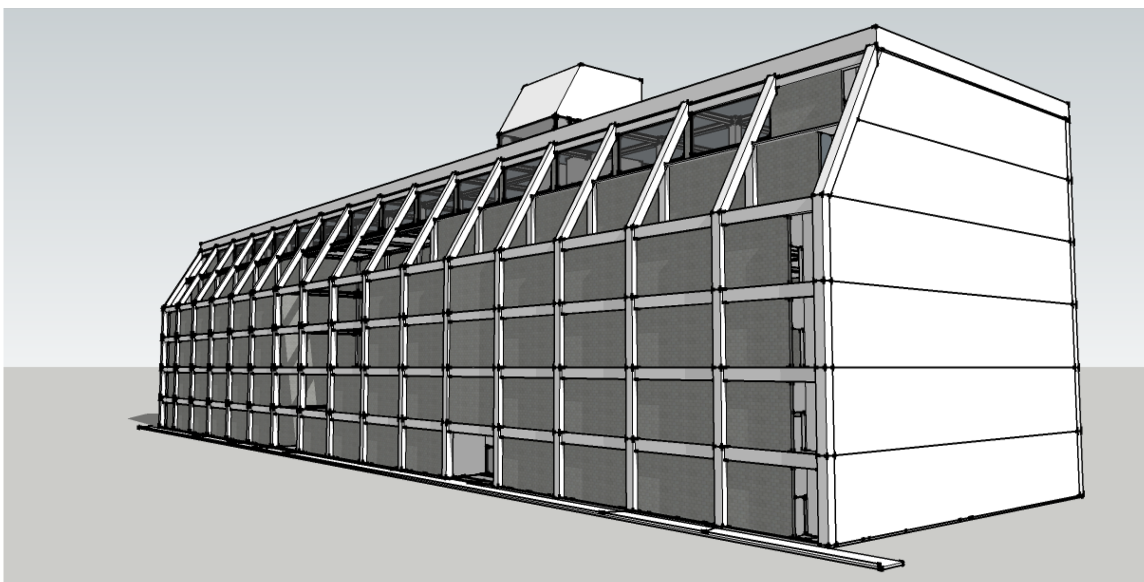

Image 54. Existing Building Perspective - Structure vs. Infill Wall[242]

[241] Image by Author.
[242] Image by Author.

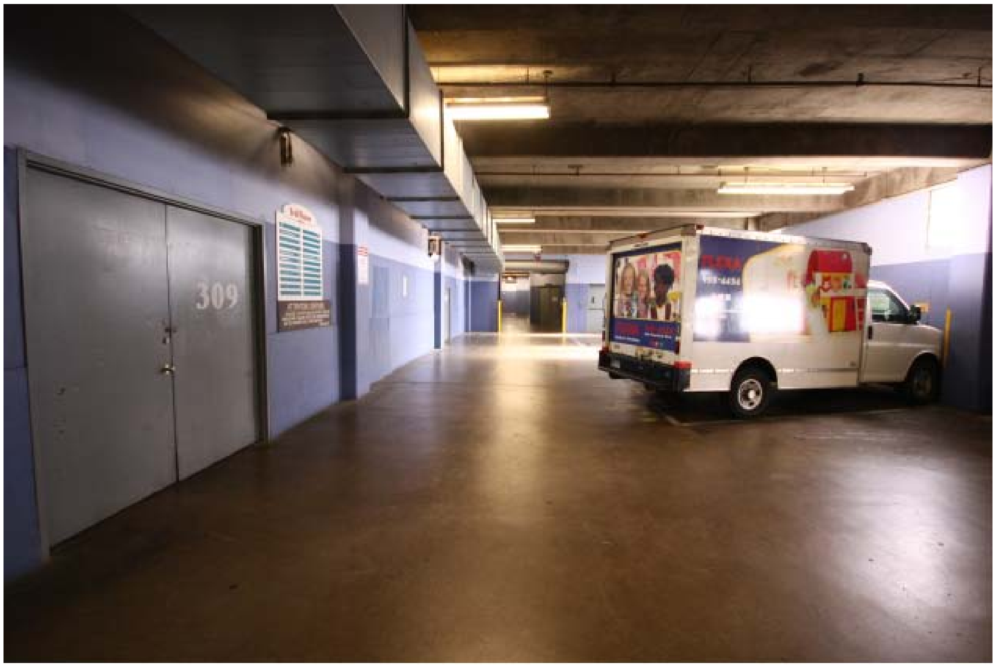

Image 55. Photo of Existing Parking Area on 3rd Floor[243]

Image 56. Photo of Existing Corridor Conditions, Third Floor[244]

[243] "Property Information." *875 Waimanu Street, Kakaako Commerce Center.* Loopnet.com <http://www.loopnet.com/Attachments/D/B/8/DB82AA06-1CC7-4DCC-8412-DA7289D91B70_tn.jpg> (Accessed January 24, 2012).

The existing corridors are approximately 12’-0” wide which permits vehicular access to majority of tenant spaces on the first five floors for loading and unloading merchandise.

Image 57. Existing Corridor Conditions, Fifth Floor[245]

Image 58. Photo of Existing Circular Vehicular Ramp[246]

[244] “Property Information.” *875 Waimanu Street, Kakaako Commerce Center.* Loopnet.com <http://www.loopnet.com/Attachments/5/6/7/567467C7-803B-44A7-AF00-17BE5EE5D85B_tn.jpg> (Accessed January 24, 2012).

[245] Images by Author.

Image 59. Panoramic Photo of Existing "Unit" (Suite #524) Looking Toward Corridor[247]

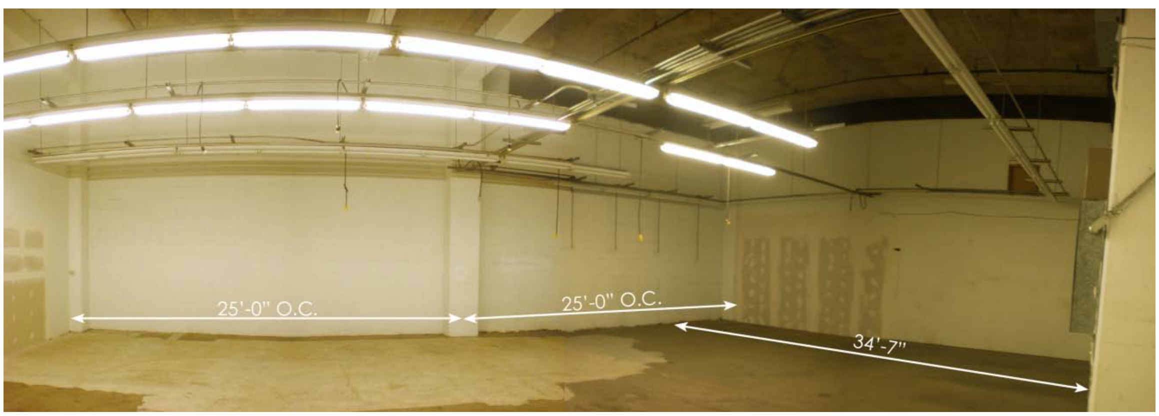

Image 60. Panoramic Photo of Existing "Unit" (Suite #524) Looking Toward Exterior Wall[248]

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[246] "Property Information." *875 Waimanu Street, Kakaako Commerce Center.* Loopnet.com <http://www.loopnet.com/Attachments/6/D/3/6D3E68B3-8E3B-4418-A02C-CCB1E65342FD_tn.jpg> (Accessed January 24, 2012).

[247] Panoramic image composed by author.

[248] Panoramic images composed by author.

Building Code Compliance

Because this project is an adaptive reuse project, it must comply with the requirements set forth by the 2003 International Existing Building Code.[249] This project involves a change of use from a low-hazard F-2 occupancy to a higher hazard mixed-use occupancy of residential group (R-2), business group (B), and mercantile group (M) occupancies. For the most part, this involves upgrading most of the electrical, plumbing, and fire safety systems to meet the requirements of these higher occupancy standards.

[249] *Revised Ordinances of Honolulu*, Chapter 16: Building Code, Section 101.2 (Exceptions), 16-1.

3.3 Design Concept and Program Development

Since the property is currently not in a desirable area for residential development, the design will include a mixed use of residential, commercial and office spaces. This mix will provide a buffer between the industrial neighborhood and this project's residents. The additional rents generated from the office and commercial areas can also help in generating income to offset some of the costs for developing the project.

Commercial and/or industrial uses would continue on the ground floor; however a substantial amount of renovation would be done at the ground level to accommodate more tenants and introduce the idea of an interior street as a means of interacting with the existing conditions of the neighborhood. The dividing up of the ground floor into smaller tenant spaces enables the area to accommodate a variety of tenant sizes. Along the Waimanu facade, the building line is pulled back to accommodate one row of guest parking stalls. Maintaining street access from the Waimanu Street side of the building allows for ease of loading and unloading zones for machinery, materials, etc.

Image 61. Development of Ground Floor Plan[250]

Because a level of standardization needs to occur in order to control costs of a housing project, the driving idea behind the project design began with the idea of creating prefabricated dwelling modules that can essentially be inserted into the existing building structure and be 'plugged'

[250] Images by Author.

into the plumbing, electrical, and telecommunication system. This concept is very similar to Schneider and Till's Bottle Rack Principle (see page 54).

Because the existing plumbing chases are located at either end of the building, sewer discharge from each unit needs to run along the length of the building. In the initial stages of the design process, the idea of raising the dwelling unit floor 18" above the existing concrete floor to allow for uninterrupted water and sewer flow to and from dwelling units was considered.

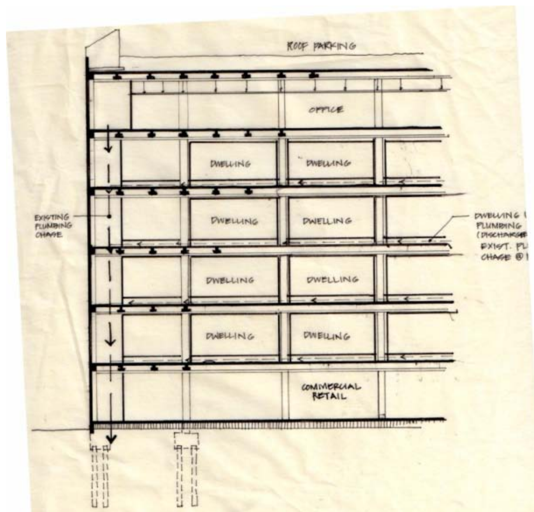


Image 62. Partial Longitudinal Section Sketch Illustrating Sewer Discharge[251]

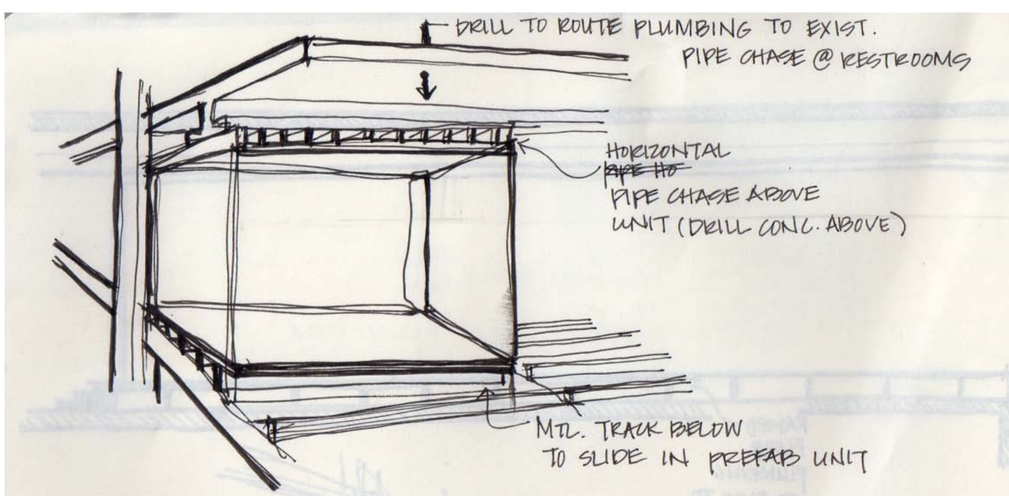


Image 63. Initial Concept Sketch of Prefabricated Residential Unit[252]

[251] Image by Author.
[252] Image by Author.

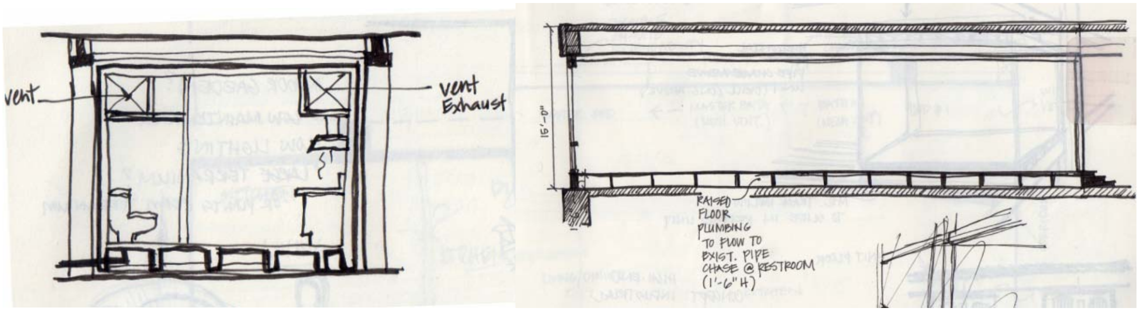
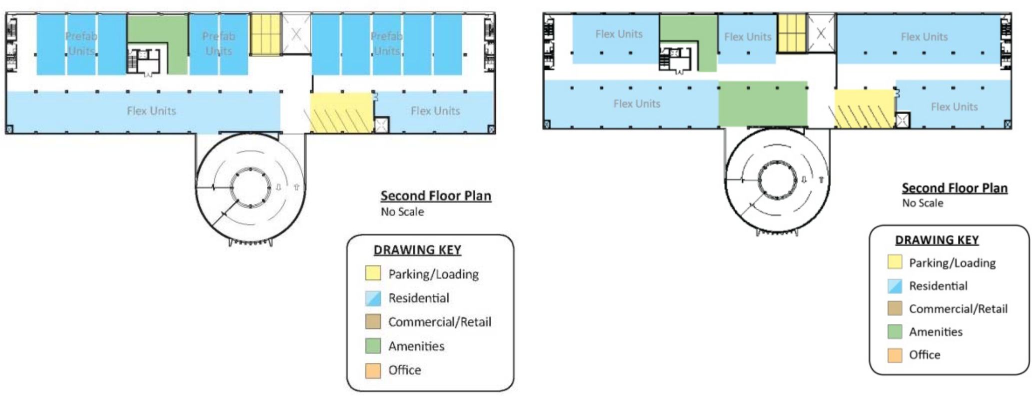


Image 64. Sketch of Prefabricated Residential Unit Sections[253]

However, the design concept created numerous complications in terms of enabling flexibility between units and transporting and installing the dwelling units. The constraints of the project site and its existing structure further limited the amount of prefabricated units that would be able to be installed. Therefore a different design approach was necessary. Instead of complete unit prefabrication, the design utilizes prefabricated kitchen and bath modules that are more easily transported and installed within constructed in-place unit shells.



Although the ability to combine and divide units were to be inherent in the design of the units, a maximum number of units needed to be set in order to determine parking requirement loads. Therefore, each usable structural bay was considered to be one dwelling unit.

The maximum number of dwelling units however was limited to the existing conditions on site. Three structural bays on each residential floor behind the circular vehicle ramp were replaced with an amenity space per floor since its location did not allow for any windows and was therefore unsuitable for residential units. This increased amenity space could yield more parking, accommodate building service spaces, or maybe additional office spaces (bringing 'mixed-uses' to all floors…like a traditional street neighborhood).

Initially, the existing offices on the sixth floor were to remain as leasable office space with minor improvements to avoid additional costs. However, because of the low dwelling unit density

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[253] Images by Author.

generated from existing building conditions, converting the sixth floor office spaces to penthouse residential dwelling units should occur to take advantage of the unobstructed sixth floor views.

Target Market: the Creative Class

During several committee meetings for this project, it was suggested that the building be designed and branded in such a way to appeal to the budding Honolulu artist community in order for the project to be successful. By doing so, the notion of user participation could be aesthetically controlled since artists and others who are involved in creative occupations have an eye for design.

Research for understanding the identity of Honolulu's artist community was primarily acquired through University of Hawaii School of Architecture alumni Raquel Gushi's doctorate project on arts and cultural districts. In her thesis, Gushi describes two different identities for arts and cultural districts: 'high culture' districts and districts aimed for the 'creative class'.[254] High culture districts are usually determined by government and include establishments and venues that are generally intended for audiences with higher incomes (e.g. symphonies, art museums, concert halls, etc.). The Creative Class includes people whose occupations involve some form of creativity or artistry. The spatial identity of the Creative class is grittier and more concerned with the production of art and culture rather than the consumption of it.[255]

Kakaʻako is sort of the middle ground between the Honolulu Cultural District (which includes 'high-culture' establishments such as the Neal S. Blaisdell Center and the Honolulu Academy of Arts) and the Chinatown Historic District (which includes creative class venues like artist studios and galleries). Given its existing industrial character, the Central Kakaʻako neighborhood in its existing condition would likely appeal to members of the creative class who prefer diversity of uses, active public realms, adaptability, and economical, available space. Because of its location between two distinctive arts and culture districts the gentrification of Kakaʻako seems inevitable. However, it can be assumed that young urban professionals, who are attracted to arts & cultural districts, once these districts are established, are more likely to be able to afford the market rate housing that is provided by other Kakaʻako housing developments.

The creative class forms strong associations between physical space and the cultural product being created and consumed.[256] Central Kakaʻak o has a strong industrial identity. For this reason, residents for this project are likely to be the industrial designers, sculptors, potters,

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[254] The term 'Creative Class' is identified and defined by Richard Florida in his book *The Rise of the Creative Class,* (New York, Basic Books, 2002).

[255] Raquel Nozomi Gushi, "Community Self-Analysis and Temporary Intervention in Arts and Cultural Districts" (Doctorate of Architecture diss., University of Hawaii, 2011),

[256] Raquel Nozomi Gushi, "Community Self-Analysis and Temporary Intervention in Arts and Cultural Districts" (Doctorate of Architecture diss., University of Hawaii, 2011), 10-14.

crafters, etc. rather than painters or performers. The goal of this residential project should be to cater to the neighborhood's industrial image, but be more habitable.

This project design also aims to take advantage of indoor/outdoor relationships and Hawaii's natural climate to differentiate this project's identity from the typical 'U.S. urban loft' and make it authentic to Hawaii.

Supportive Commercial Uses: Design Labs

The lack of adequate parking and industrial characteristics of the neighborhood is less likely to support the traditional retail, restaurant and commercial businesses that are associated with residential mixed use developments in Honolulu, at least at this point in time. It therefore makes sense to be market this project to the 'Creative Class', to attract new types of commercial uses that would appeal to the creative and inventive nature of its intended residents and the existing neighborhood.

The following commercial spaces are examples of commercial uses that embrace notions of flexibility while being a benefit for artists, industrial designers, and other members of the creative class. The idea is that the businesses and commercial space of the building not only are sources of income to offset the costs of the building but that their services benefit and supports the residents and neighborhood as well.

Membership-based Fabrication Workshops

Where co-working spaces are geared more toward the computer and business clientele, fabrication workshops, such as TechShop,[257] are open industrial workshops that allow members shared use of various tools and equipment such as industrial sewing machines, automotive floor jacks, welding equipment, laser cutters, etc. for a membership fee. These workshops employ staff who conduct classes and provide services such as safety briefing, training, consulting and prototyping to assist and ensure safety of the workshop members. Members who utilize the fabrication workshop can be someone looking to fix or tune up their cars, build a piece of furniture for personal use, or creating product prototypes for a startup company.[258] TechShop, the precedent study for these types of workshops, is an existing franchise. One of the proposals for this project could be for the developer to either aim to attract existing fabrication workshop franchises like TechShop or to form partnerships with local builders/businesses to create an independent workshop for this project.

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[257] *TechShop.* <http://www.techshop.ws/index.html> (Accessed April 2, 2012).
[258] *TechShop.* <http://www.techshop.ws/index.html> (Accessed April 2, 2012).

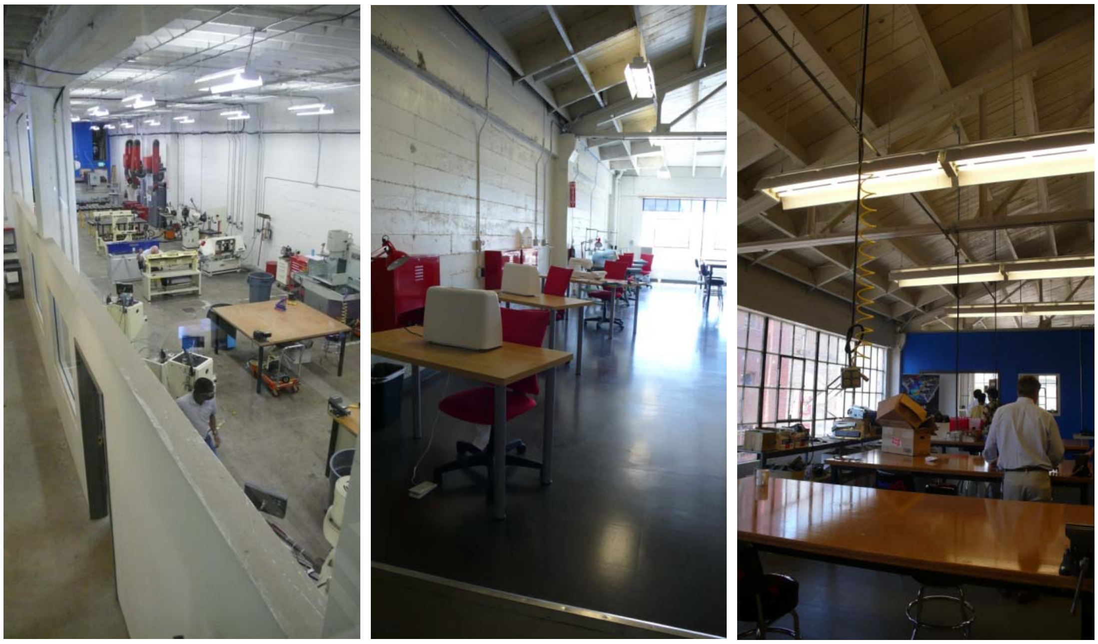

Image 65. Membership-Based Fabrication Workshop Precedent: TechShop (San Francisco)[259]

If used in conjunction with the aforementioned co-working spaces, these fabrication workshops could aid in small-start up business growth. Product prototypes could be developed in the fabrication workshop while the business end can be developed and realized in the co-working environment. The workshop can also be a resource for the small industrial businesses in the surrounding Central Kaka'ako neighborhood as well in the event that they need use of specialty machinery that their business does not own or cannot afford to purchase.

Another benefit of the fabrication workshop is that this space can initially serve as the location in which the prefabricated elements and panels are assembled. This would minimize transportation costs of the dwelling unit elements from an off-site production/manufacturing location to the building site. Although the size of the workshop would not be at the level needed to achieve the level of speed associated with traditional prefabrication and factory-assembled workshops, a fair amount of tools and machinery would still be available. Furthermore, local labor can be utilized which may help offset opposition from labor unions against prefabrication and manufactured housing. It would also provide sheltered storage location for most of the materials reducing one factor of construction waste. Once the renovation construction is complete, the fabrication workshop can be converted to a membership-based fabrication workshop described above.

One of the big concerns with this proposal is the potential exposure to fumes, dust, and other air-borne particles generated by industrial activities. However, for this specific project the existing building already has mechanical ventilation systems in place. Whether or not this is

[259] Image by author. "TechShop." San Francisco, CA. March, 2011.

adequate to continue light industrial use on the same site as residential has yet to be determined.

Artist & Design Studios/Design Labs

Artist studios allow residents of this project to live and work in the same building, removing the need for commuting (even short distances). The spaces can be smaller than the typical 25'-0" wide bay or can be combined with adjacent studios to form large collaborative studios. Studios for sculptors, painters, and industrial designers can be located at the ground level. Studios for graphic designers, architecture firms, etc. can be located on the 6th floor office level.

Image 66. Artist Studio Precedent: Kristan Horton Photography Studio (Toronto)[260]

[260] "KrystianStudio." Blog post July 19, 2010. <http://artmatters.ca/wp/wp-content/uploads/2010/07/IMG_3923.jpg > (accessed May 1, 2012).

Co-working spaces

Co-working spaces are shared work environments for independent professionals, freelancers, etc. They are provided as an alternative to working in coffee shops and cafes or in isolated home offices. The idea behind co-working is that these spaces encourage more efficient work habits since its users are removed from the distractions of their residential spaces, as well as foster more creativity, collaboration, innovation, education and inspiration through working in proximity with like-minded individuals.[261]

Most co-working spaces are used by computer programmers and web designer [262] and provide wireless internet access, access to printers/copiers/scanners, coffee and water, shared use of rooms and desks, a physical mailing address, tech support, and equipment rental. An existing co-working space in Kaka'ako known as the Greenhouse listed several possible features that co - working spaces can include such as meeting/teleconference spaces, presentation/teaching spaces, soundproof studios with support for recording/mixing/editing, adaptable video studio or set with green screen for recording/editing, fabrication workshops, and gallery spaces for exhibits, demonstrations, performances, and community events.

Image 67. Coworking Precedent Study: The Hub (San Francisco)[263]

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[261] "Coworking towards the Future." *The Greenhouse.* <http://www.higreenhouse.com/ourstory/> (Accessed April 2, 2012).
[262] "Coworking Study: The Coworker." *Deskmag.* < http://www.deskmag.com/en/survey-coworking-spaces-144> (Accessed April 2, 2012).
[263] Image by author. "The Hub: Coworking Spaces." San Francisco, March 2011.

Amenities and Common Areas

Because of the location of fixed elements such as the elevator cores, public restrooms, stairwells, fifth and sixth floor setbacks, and parking ramp, the building ends up with a lot excess space that cannot be used as dwelling units. These excess spaces can be instead used for amenities for the residents. The following spaces are to be provided in order to attract residents with creative occupations. They may also serve as gateways to display resident work and in some cases provide opportunities toward developing start-up businesses.

Move & Play Areas

Fitness Center

Gyms and fitness centers are somewhat typical in most residential development projects but relevant to this project nonetheless.

Outdoor Play Areas

Although the target client market is not overwhelmingly families with young children, it is still a good idea to provide amenities for children in the event that young families end up being attracted to the building and would like to settle here. This could become a possibility in the event that gentrification of this neighborhood in Kaka‘ ako occurs, opening up the market to people beyond the creative class. The provision of an outdoor fitness area that includes things such as balance beams, chin-up bars, sit-up benches, monkey bars etc. can be provided for use by both children and adults.

Eat & Entertain

Eating and entertainment spaces are often provided by most mixed use residential developments as part of their amenities spaces that residents are able to reserve for parties and gatherings. Outdoor BBQ spaces could be provided on one of the outdoor terraces. A clubhouse with a large kitchen can also be included nearby for large parties.

Show & Tell Spaces

Because the project is geared toward the Creative Class, the project is likely to benefit by providing areas which showcase some of the creative talent of its residents. This could be done by providing some of the following spaces for residents to rent or reserve use:

- Performances spaces for plays and mini-concerts
- Indoor movie theater / projection room for movie screenings and/or presentations
- Rehearsal rooms for musicians
- Open market space for impromptu craft fairs, flea markets, and art exhibitions
- Indoor Art Galleries
- Mini Outdoor Sculpture Parks

Image 68. Rendering of Stage/Market Space (Ground Floor)[264]

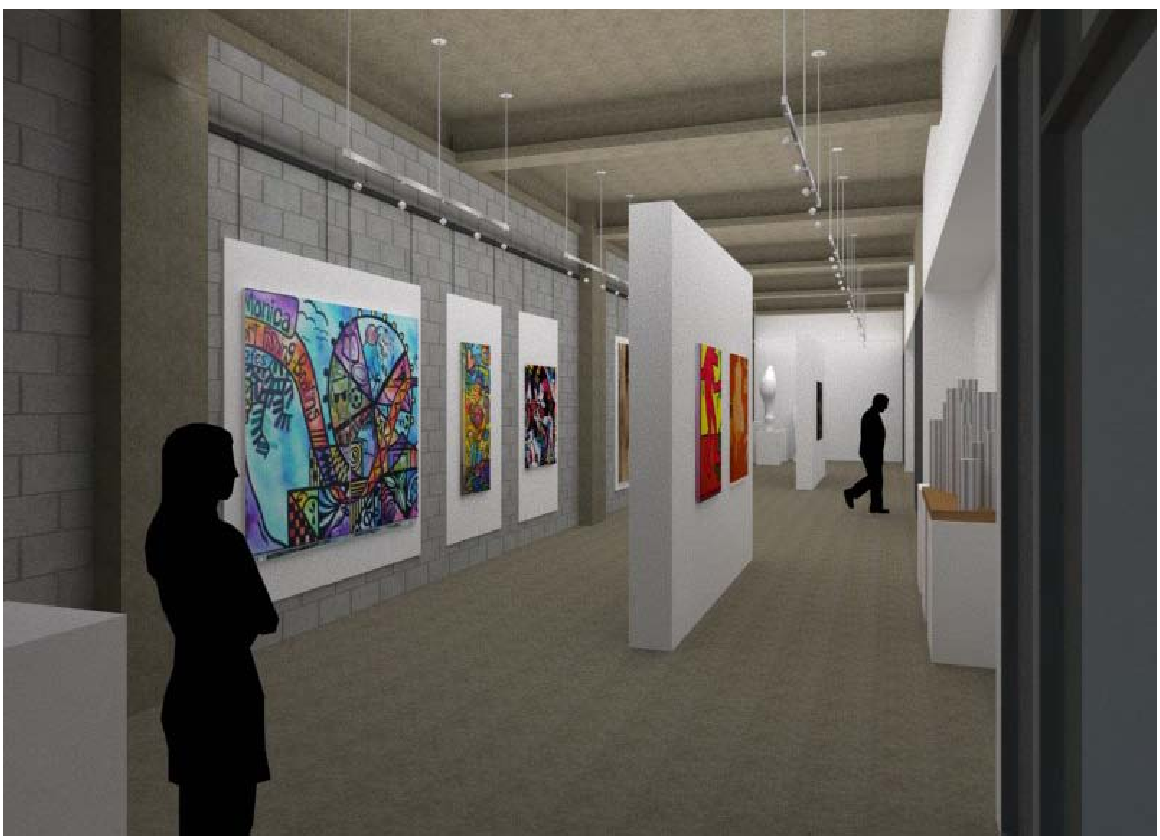

Image 69. Rendering of Fifth Floor Gallery Space[265]

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[264] Image by Author.

3.4 Overall Building Design Concepts

The following sections describe the major design concepts for the overall building. These concepts were generated from existing building and site conditions.

Interior Streets

The excess circulation space is an opportunity to create usable indoor public space that can bring the 'street' above the ground level and create a neighborhood within the confines of the building. The allowable structural loads granted by the existing building as well as its existing mechanical system for car exhaust allows for vehicular access and parking on the first five floors. This allows for some users to park closer to their units than would otherwise be allowed in the conventional high-rise apartment building where parking is confined to a parking garage on the first six floors or so.

Although the practice of having excess circulation space is usually frowned upon in typical high-rise residential developments, from the standpoint of developing residential identity, it actually is a favorable one. Larger indoor circulation space also provides opportunity to expand dwelling units into the public realm as well as accommodate a variety of gathering areas such as indoor gardens, indoor play areas, or communal work spaces (like the work spaces at Starbucks, perhaps). The ends of the corridors can also include glass windows or maybe even be open air, to allow light and natural ventilation – commodities that are trying to gain more popularity in multifamily urban residential design.

Image 70. Rendering of "Interior Street Concept" (Second Floor Shown)[266]

[265] Image by Author.

[266] Image by Author.

Facade Improvements

The existing building structure is a poured-in-place concrete frame with slab floors. Hollow concrete block is used as infill walls along the exterior of the building and can theoretically be removed with minimal damage to the concrete frame. The potential to remove these hollow concrete block walls provides great opportunities for aesthetic improvement of the Mauka and Makai facades of the building as it helps break up the building into smaller masses simply through changes in transparency, materials, and color.

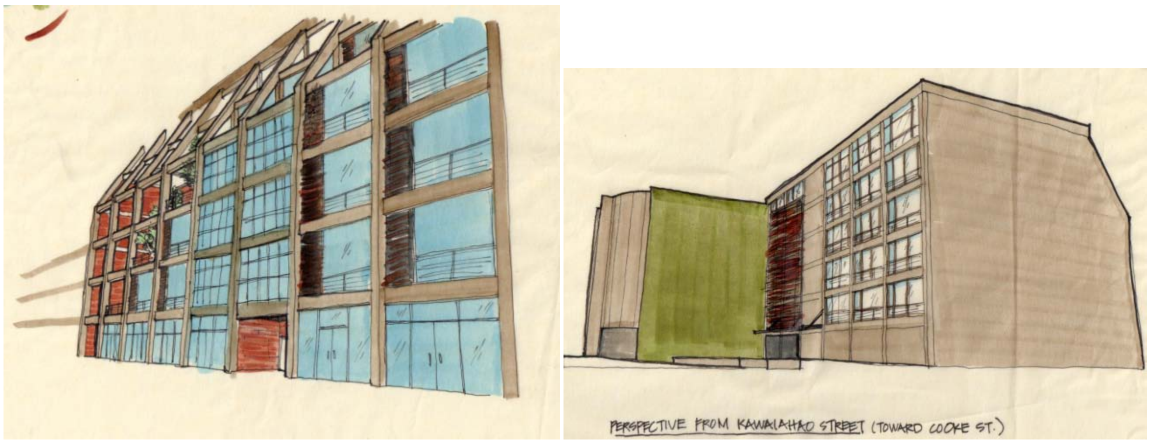


Image 71. Conceptual Sketches of Waimanu (L) and Kawaiahao (R) Facades[267]

Image 72. Waimanu Street Façade Rendering[268]

[267] Images by Author.

[268] Image by Author.

Design Issue: Zero Lot Line

One major problem is addressing the building's zero lot line construction. The existing structure has been built right up to the property line on most sides of the lot. The Mauka Area Plan also does not require any side or rear yards in the Central Kakaako neighborhood. This creates a significant issue concerning the possible development of adjacent properties along the Kawaiahao Street facade. According to Figure NZ.5 in the Mauka Area Rules these properties are allowed to be built up to 65'-0".[269] In the worst case scenario that these properties are developed to the maximum height, it would block the views, light and natural ventilation opportunities for the first three floors of residences along the Kawaiahao Street facade.

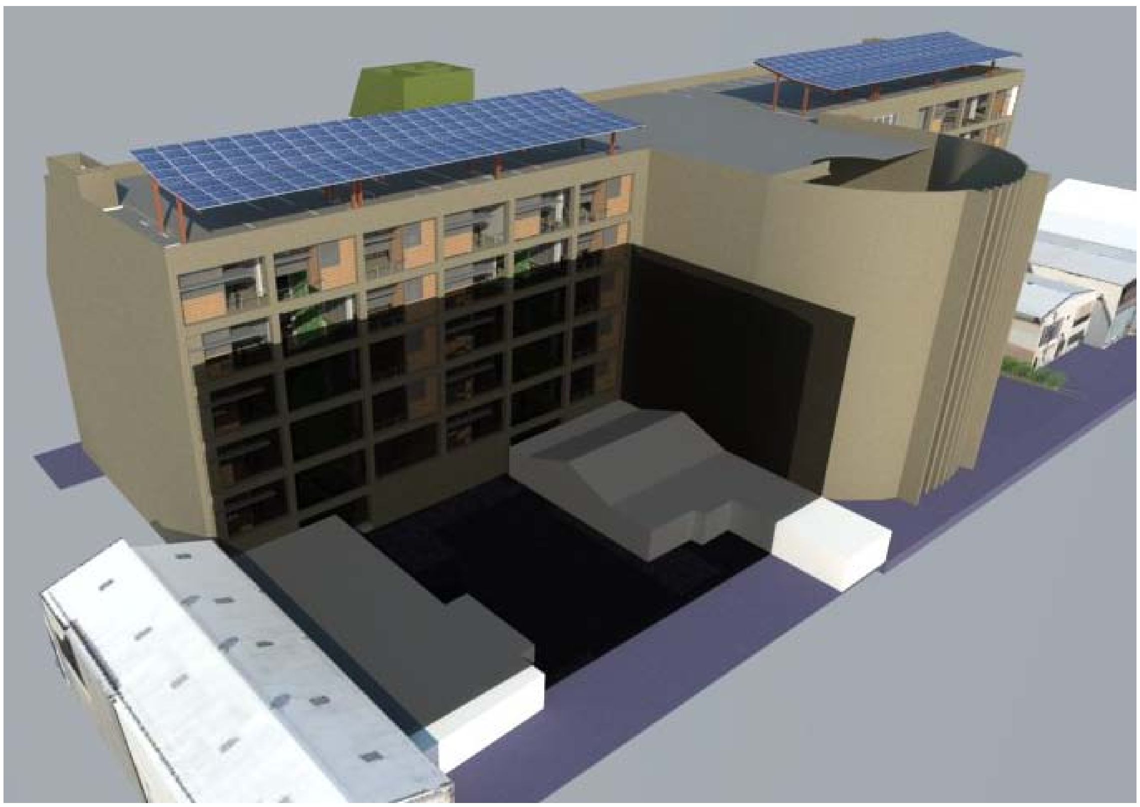


Image 73. Kawaiahao Facade with Maximum Height Development on Adjacent Properties (Shown in Black)[270]

Three design schemes were developed to address the issue of the zero lot line: Lot Acquisition, Light Wells, and Atriums. Because each design scheme affected the unit count, cost parameters, and parking requirements differently, an exploration of all three were developed conceptually in order to analyze which approach would be the most feasible and beneficial.

[269] Hawaii Community Development Authority. Figure NZ.5 "Central Kakaako (CK) Zone." *Mauka Area Plans and Rules.* http://hcdaweb.org/kakaako/plans-rules/mauka-area-plan-and-rules/Neighborhood%20Zone%20NZ.1-7.pdf/download

[270] Image by Author.

Design Option 1: Lot Acquisition

The Lot Acquisition scheme involves purchasing the six adjacent lots along the project's Kawaiahao Street property lines in order gain control over the future development of these properties. The acquired properties can then be developed with the rest of the project as either at-grade park or open space or a 1-story commercial addition with a rooftop garden or terrace. Doing so not only maintains the desirable makai views of the residences on the Kawaiahao façade, but also provides the added benefit of meeting HCDA's open space requirement for new developments. In other design schemes, this requirement would be waived in lieu of a fee.

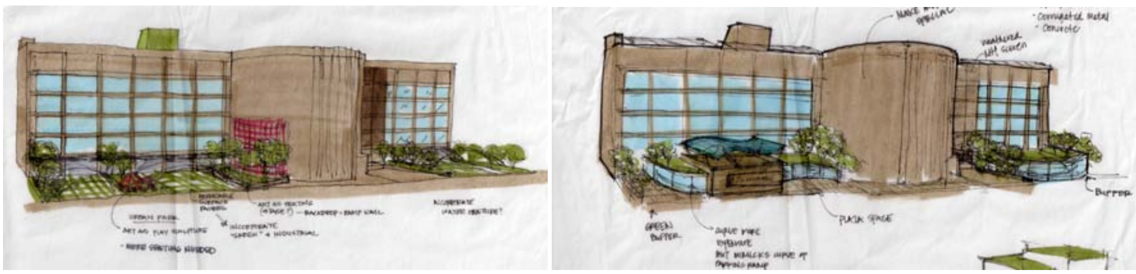
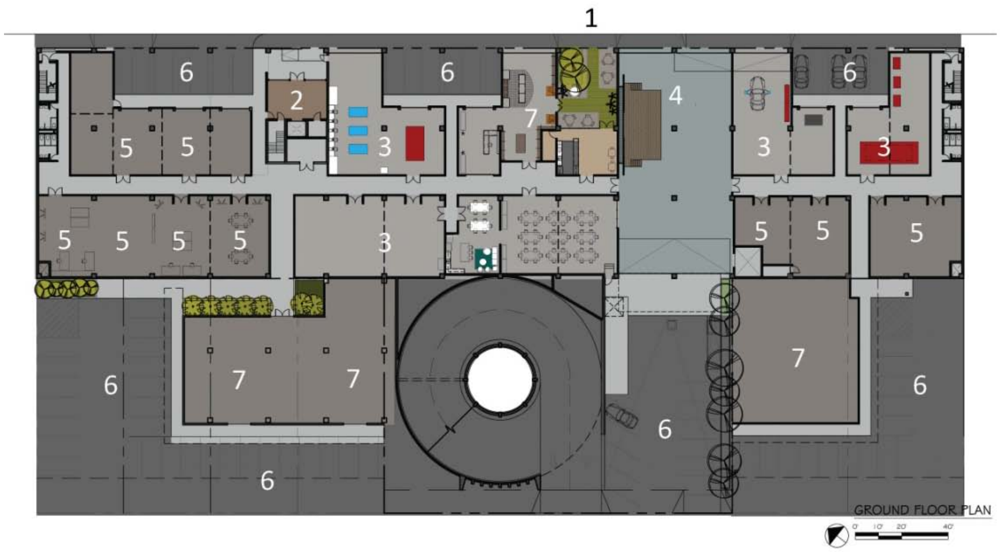


Image 74. Exterior Concept Sketches of Property Acquisition Schemes – At-Grade Park (L), Roof Terrace Park (R)[271]

The one-story commercial addition with rooftop garden is the more beneficial for the project since commercial space on the ground level can generate income to help offset the land acquisition and new construction costs. While one-story commercial also generates more parking requirements, additional parking can also be incorporated at the ground level as needed. The floor plan below shows the basic programming for the ground floor acquisition scheme with single story commercial use.

[271] Images by Author.



DRAWING KEY

1 Atrium
2 Lobby
3 Fabrication Workshop
4 Performance & Public Market Space
5 Artist Studios
6 Parking
7 Small Retail/Showroom

Image 75. Acquisition Scheme Ground Floor Plan[272]

The rooftop garden or terrace is on the same level as the residential units that begin on the second floor. The second floor looses two dwelling units to provide access to the rooftop terrace above the new commercial space, but this significantly less than the amount of units lost in some of the other design schemes.

Setting the new commercial space back from the existing structure, incorporating tall planting along the ground floor walkway and providing planting along the edges of second floor rooftop terrace creates a privacy and security buffer between the public roof terraces and the private unit balconies in the near proximity.

[272] Image by Author.

DRAWING KEY

1	Elevator
2	Dwelling Unit (Unit Type)
3	Fitness Center
4	Public Restrooms (Existing)
5	Staircase
6	Parking
7	Outdoor Terrace
8	Outdoor Fitness Area
9	Outdoor Play Area
10	BBQ Area

Architect and committee member Geoff Lewis suggested during the final presentation covering the parking area that needs to be included to satisfy the increased parking requirements and extending the rooftop terrace over the parking lot. The rendering below illustrates this suggested change. Photovoltaic shading devices were also added over the entries of the new commercial space to help reduce energy consumption for these spaces.

Image 76. Rendering of Kawaiahao Street Facade - Acquisition Scheme[273]

[273] Image by Author.

Image 77. Rendering of View from Kawaiahao Roof Terrace[274]

[274] Image by Author.

Design Option 2: Light Wells

A less invasive and potentially less expensive option is to set the units back from the building facade through the use of balconies and cut through a portion of these balconies to create light wells that at least bring in natural light and ventilation into the unit. The benefit of this option is that it maximizes the number of residential units while enabling the unit layout to remain more or less standardized. However, in the event that another developer builds up to the maximum height limit on the adjacent properties along Kawaiahao Street, eliminating the view for almost all of the units along that facade.

Image 78. Conceptual Rendering of Light Well Scheme in Existing Conditions (L) and in Worst-Case Scenario (R)[275]

[275] Images by Author.

KEY

1 Atrium
2 Lobby
3 Fabrication Workshop
4 Performance & Public Market Space
5 Artist Studios
6 Parking

KEY

1 Elevator
2 Dwelling Unit (Unit Type)
3 Fitness Center
4 Existing Public Restrooms
5 Staircase
6 Parking
7 Outdoor Terrace

Image 79. Rendering of View from Balcony of Light Well Scheme[276]

[276] Image by Author.

Design Scheme 3: Atriums

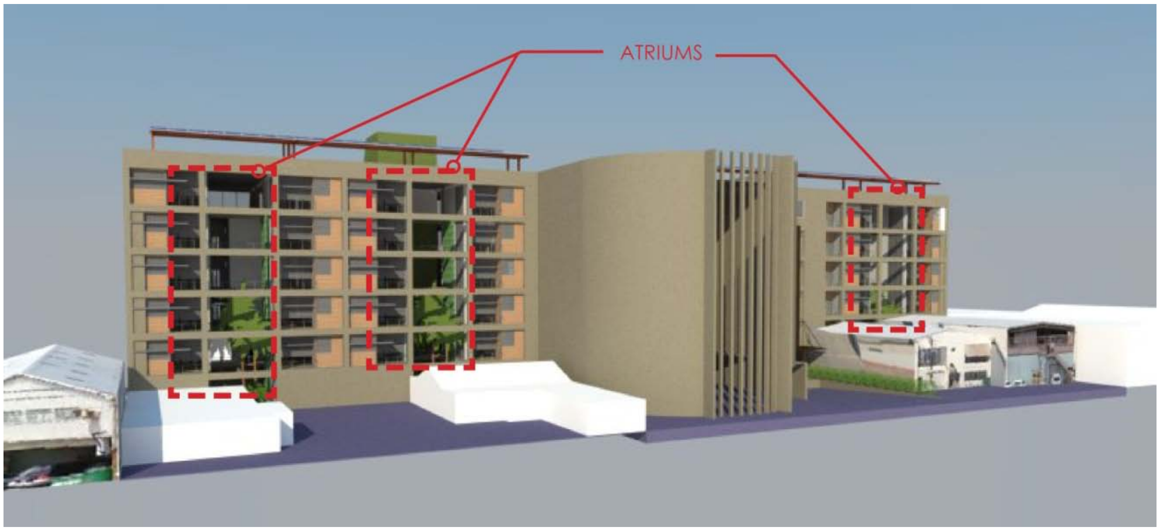


Image 80. Illustrative Image of Atrium Scheme[277]

This option involves the development of three vertical dwelling unit stacks along the Kawaiahao street facade and creates outdoor atria between residential units along this side of the building. By cutting through some of the concrete floor slab and changing out a portion of the dividing wall to glazing, the view from the units is redirected inward in the event that the adjacent lots on Kawaiahao Street are redeveloped to its maximum allowable height. The each atrium is located so that almost every unit along the Kawaiahao façade (except for one) retains a view and access to natural light and air. The use of tall narrow plants such as palms or tall-growing bamboo can provide the height necessary to ensure desirable views up to the fourth floor. Vertical planting applications (living green walls, façade greening, etc.) may also be used to create desirable views or backdrops to the tall plants in these atria. Potential problems of this scheme include cost and financial feasibility since a significant portion of the floor slab is being removed which may bring about a considerable amount of structural concerns and retrofits. Also, this scheme involves the removal of 9-12 residential units and three commercial tenant spaces on the ground floor which will ultimately drive up the price per square foot.

[277] Image by Author.

Image 81. Interior View of Atrium from Third Floor Corridor[278]

Image 82. View of Atrium Space from Unit[279]

[278] Image by Author.

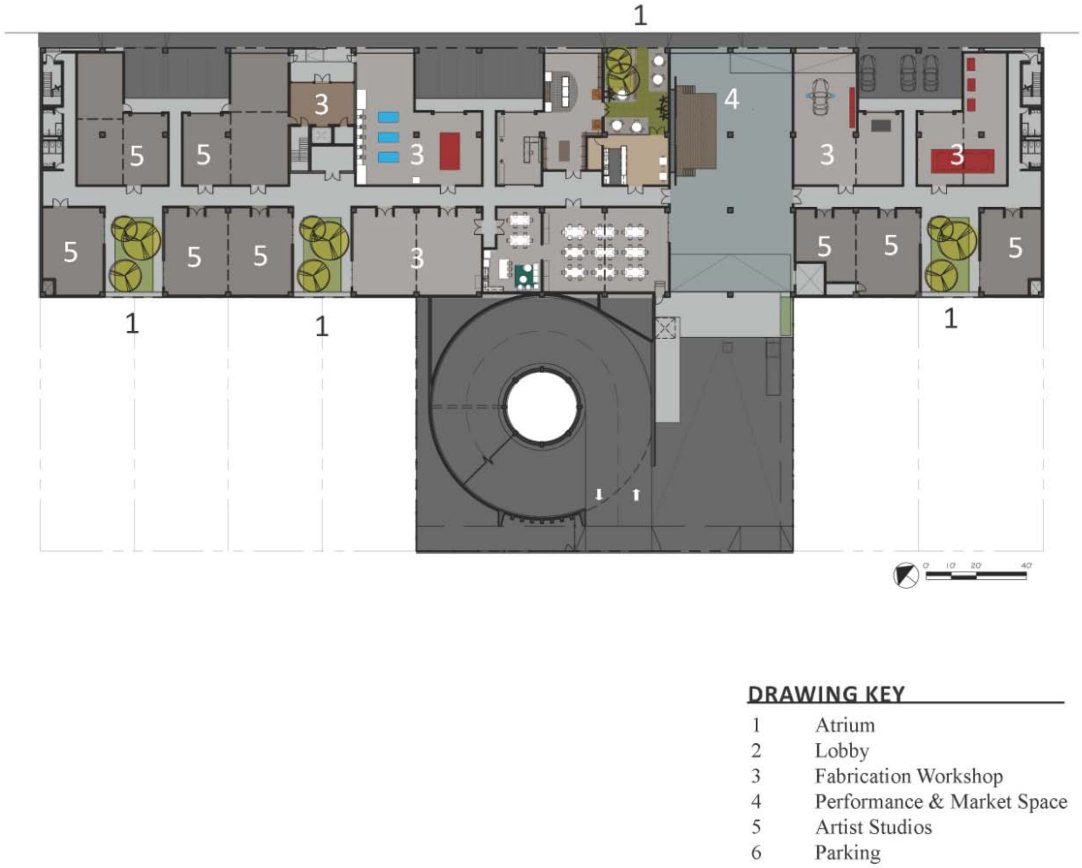


Image 83. Ground Floor Plan for Atrium Scheme[280]

These atria help break up the interior corridor and provide pleasant views for ground floor artist studios as well as residents travelling through the residential corridors on floors 2-6.

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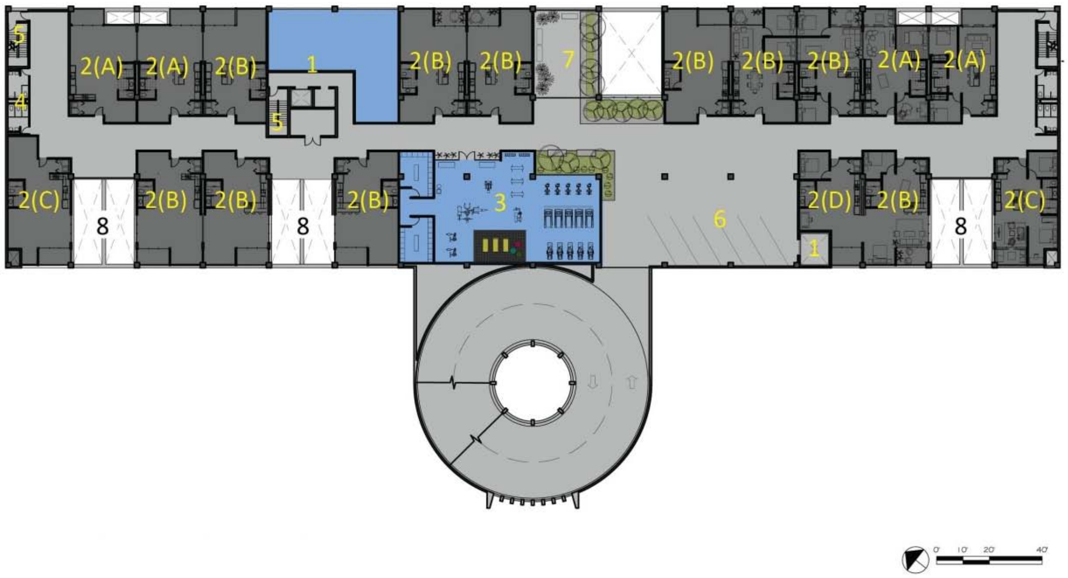
[279] Image by Author.

[280] Image by Author.



DRAWING KEY

1	Elevator
2	Dwelling Unit (Unit Type)
3	Fitness Center
4	Public Restrooms (Existing)
5	Staircase
6	Parking
7.	Outdoor Terrace
8	Open to Below

Image 84. Typical Floor Plan (Second Floor Shown) for Atrium Scheme[281]

[281] Image by Author.

Image 85. Exterior Rendering of Kawaiahao Facade - Atrium Scheme[282]

Image 86. Interior Rendering Unit Living Area for Atrium Scheme (Kawaiahao Facade)[283]

[282] Image by Author.
[283] Image by Author.

Utilities Distribution

It is important to separate the utilities from the structural system to aide in the maintenance, repair and replacement of utilities throughout a building's life. There are two existing plumbing chases located in public bathrooms at the each end of the building.

The existing building's structure consists of 2'-0" square columns and 1'-4" wide beams. In order to allow for plumbing distribution that does not conflict with the structural system, the plumbing and electrical systems are intended to be bored through the 5" concrete slab and connected to a centralized plumbing chase on the ceiling of the floor below.

In the diagrams below, the red line diagram on the left indicates the plumbing distribution while the diagram on the right demonstrates the potential expansion of units based on the plumbing scheme organization in relationship to the building structure.

Image 87. Diagram of Wet Zone Locations *Between* Structure (L) and Resulting Unit Expansion Possibilities (R)[284]

Wet Zone between Structures. Locating unit wet zones at the midpoint between column lines opens up several possibilities in terms of unit flexibility. The shared plumbing zone makes for efficient use of space and material while also allowing for more variety of unit expansion. Not only can units expand into the hallway, but units can be combined in half-bay widths in certain areas.

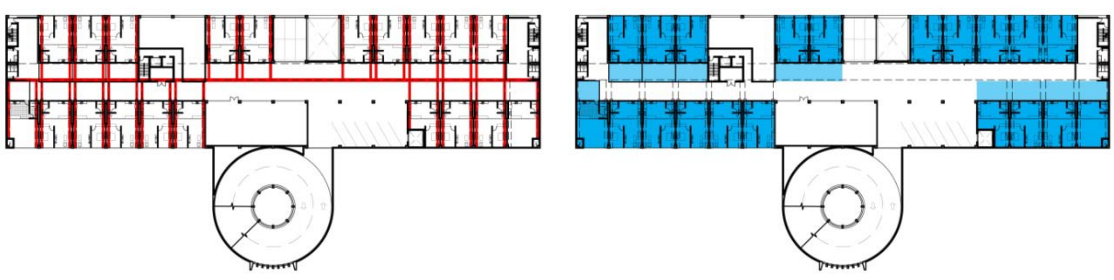


Image 88. Diagram of Wet Zone Locations *Around* Structure (L) and Resulting Unit Expansion Possibilities (R)[285]

[284] Images by Author.

Wet Zones around Structure. The images above illustrate the location of two plumbing zones along the structure. This scheme maximizes the number of residential units in the building. It also allows for dividing walls between units to be attached to the existing structure. The downside of this scheme is that a 'dead zone' is created between wet functioning rooms due to the 2'-0" column between zones. The ability for unit expansion is also limited to expansion into the building corridor or through the joining of two units.

Photovoltaic Shading Devices on Roof Deck

Providing photovoltaic shading devices on the roof deck gives shading for parked cars while generating electricity from the sun to reduce the energy demands of the building. From a cost perspective, this can be beneficial in driving down the overall building's energy bills.

Existing roof parking will need to be adjusted to accommodate the steel beams that support the shading PV system which will result in the loss of a few parking stalls. The diagram below shows the proposed layout of photovoltaic shading devices to cover single and tandem parking stalls.

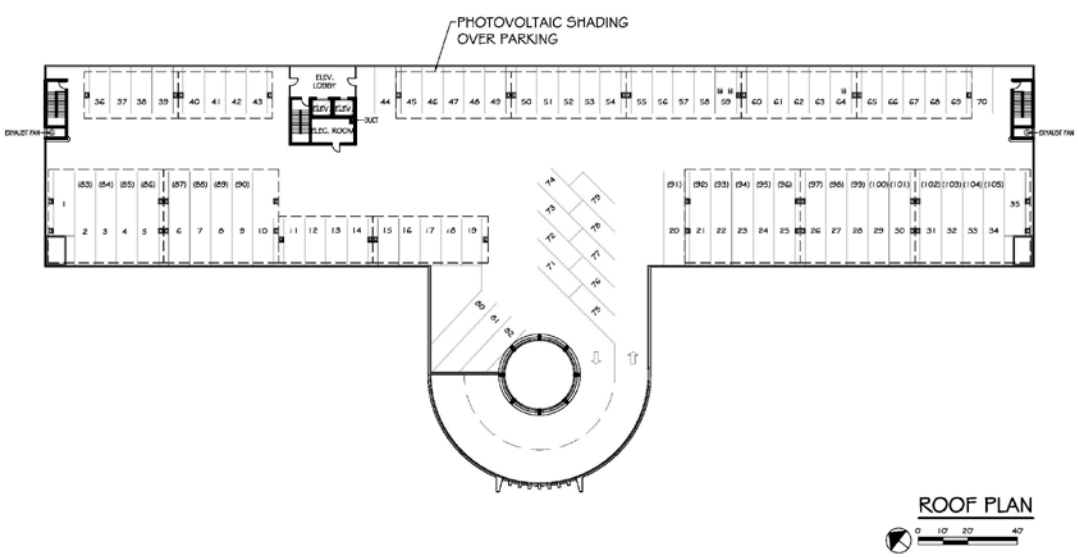


Image 89. Rooftop Parking Plan w/ PV Shading Device Layout[286]

Because the existing parking will need to be rearranged to accommodate the supports of the photovoltaic shading devices, it would be a good idea to consider widening the parking stalls on the roof deck at the same time. Currently, the parking stalls on the roof deck are only 8'-0" wide making parking problematic for larger vehicles. By widening the parking stalls to 8'-6" wide, the rooftop parking stalls becomes more accommodating to a variety of vehicle types. Although doing so would result in a loss of parking stalls, parking requirements can be accounted for on other residential floors or on the ground floor of the Lot Acquisition Scheme.

[285] Images by author.

[286] Image by Author.

3.5 Unit Designs

Although the design of the dwelling units are intended to be loft spaces, a certain amount of design needed to be employed in order to inform future users of the space of basic private/public uses. Spatial flexibility was one of the main focuses of the dwelling units. The intent for the unit design was to provide a framework that allowed residents to adapt their living spaces to fit their use. The design of these units focuses around adding spaces and combining dwelling units primarily through the use of flexible housing design tools described on page 52, such as "Rooms without Labels" and "Movable Walls."

Unit Entry & Facade Design

The design of the dwelling unit entry and the exterior facade of the dwelling unit are the points of transition between the public and private realms of the building and ultimately where the line of user participation is drawn. It is important not only for a resident in a multifamily building to be able to identify with the interior of his or her residence but the exterior as well.

Providing opportunities for resident identification at the unit entry through either changes in material, specialized signage, or some sort of display for artwork, planters, etc. helps break up the monotony of corridors. Providing elements of transparency or translucency at the unit entry also takes advantage of the high ceiling height within the dwelling unit to help draw natural light into the corridor through the units.

Image 90. Concept Sketches of Unit Facade and Entry Design[287]

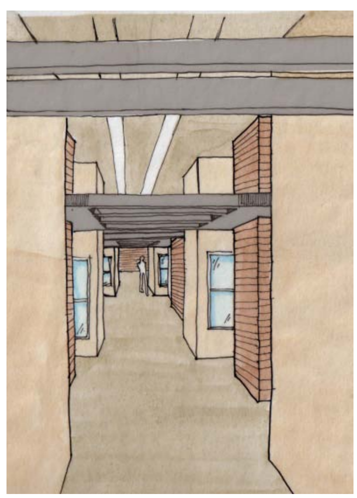


Image 91. Concept Sketch of Interior Corridor Improvements[288]

[287] Images by author.
[288] Image by Author.

Spatial Division

Although the dwelling unit is intended to be a loft type apartment, a certain amount of division of the unit is important to aide in terms of determining architectural elements that will affect the whole building such as the levels of transparency/opacity of the exterior skin, design of the public corridor, location of plumbing and mechanical systems, etc.

Each apartment unit was basically divided in half to accommodate private and social zones. The mirroring of unit plans allows for private zones in each unit to be adjacent to one another, anticipating that in the event two units would like to be combined, similar functions are already somewhat grouped together.

The implication of use should be suggested to a point, but not fully defined. For this reason, the private living spaces (bedrooms, dens, studies) are implied by the fixed and prefabricated elements within the unit, but not fully enclosed. Enclosure of these spaces for visual and/or acoustical privacy is intended to be completed by the user. This allows users to determine how many bedrooms they would like to fit within the space provided them. Perhaps they would like a larger master bedroom or a den instead of a second third bedroom. By allowing residents to interpret the use of the space, they are able to employ a level of participation in the design of their dwelling unit.

Prefabricated wet rooms (kitchens and baths) are located somewhat near the corridor and connected to the main water and sewer lines that flows to existing pipe chases. These existing chases are located in the existing public restrooms at the ends of the corridors. Because the piping for plumbing is bored through the concrete floor slab, access to plumbing for repair or replacement is handled from the unit below.

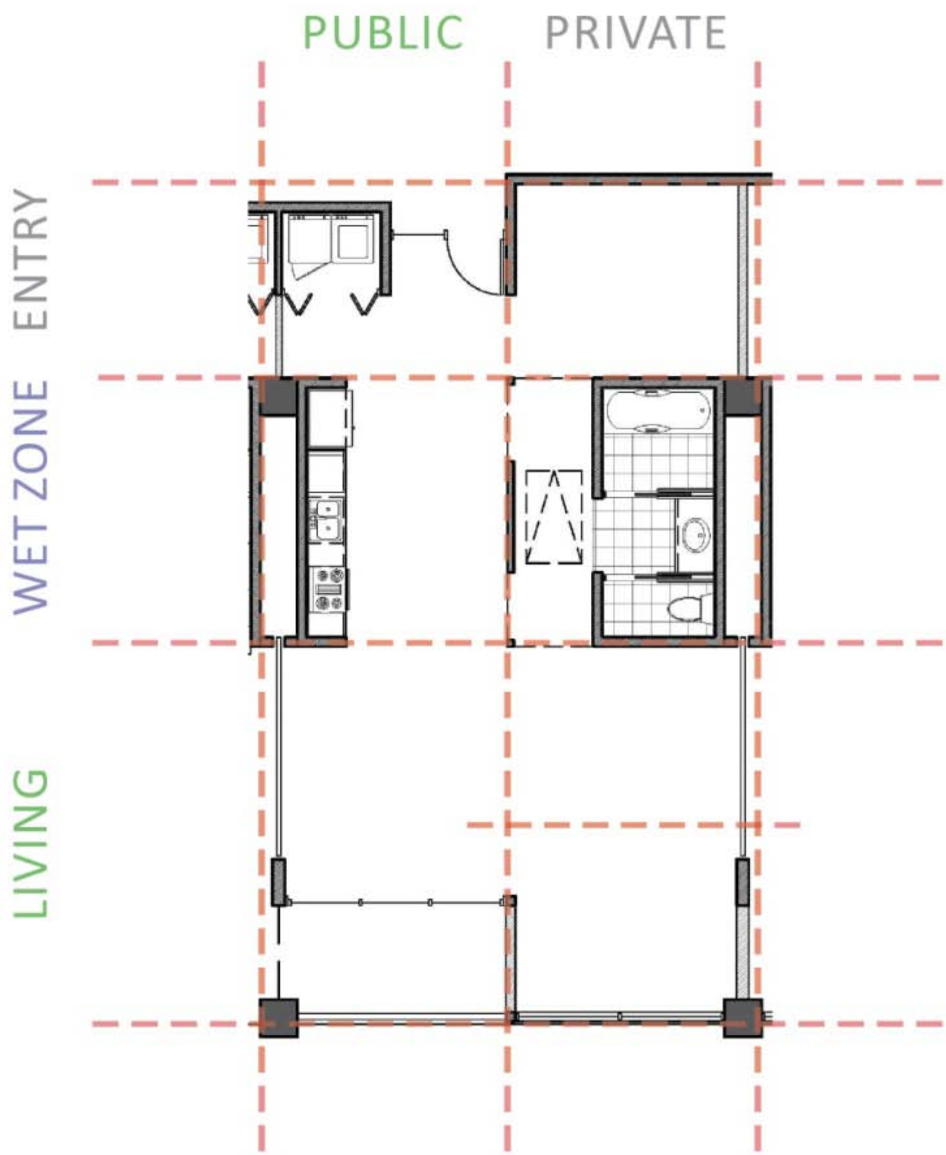


Image 92. Spatial Division Diagram of Unit[289]

[289] Image by Author.

Prefabricated Elements: Wet Modules

The unit design utilizes a combination of prefabricated kitchen, laundry, and bath modules, and movable partition walls, and sliding walls and door systems. The idea is to provide one prefabricated bath and one prefabricated kitchen per dwelling unit which is the minimum requirements for apartments. One prefabricated laundry room will also be provided per unit.

The prefabricated kitchen designs are based on a 30" cabinet module to accommodate ADA requirements for counter clearance widths as well as standard appliance widths. Depending on the type of unit, either a linear or L-shaped kitchen layout will be used. Task lighting will be incorporated into the built-in soffit above. Electrical wiring for and plumbing for the appliances and kitchen sink are to be incorporated into the prefabricated wall behind the counter. The reason that only linear and L-shape kitchens are provided is because it is easier to transport these shapes, as well as contain wiring, plumbing and lighting within the walls and cabinets of these kitchen types. Galley, U-shape and islands require more components to transport and a greater deal of on-site assembly to connect and hide electrical wiring and plumbing for fixtures and appliances. If desired, movable or nonpermanent kitchen islands can be added by the resident to add additional workspace or a dining table can be included to provide an eat-in kitchen.

Image 93. Provided Prefabricated Kitchen Types: Linear (L) and L-shape (R)[290]

Because only one bath is to be included per unit, three types of prefabricated baths will be provided. The first type is the divided bath which completely separates toilet, lavatory and bathing functions, allowing access to multiple users at the same time. This bath type is intended to be provided for larger units that have the capacity for two to three bedrooms. In order to avoid the bath opening directly into the kitchen/dining area of the unit, a privacy wall is included with this bath unit. The space between this privacy wall and the prefabricated bath also incorporates an attic ladder which provides access to bulk storage located above the restrooms.

[290] Images by author.

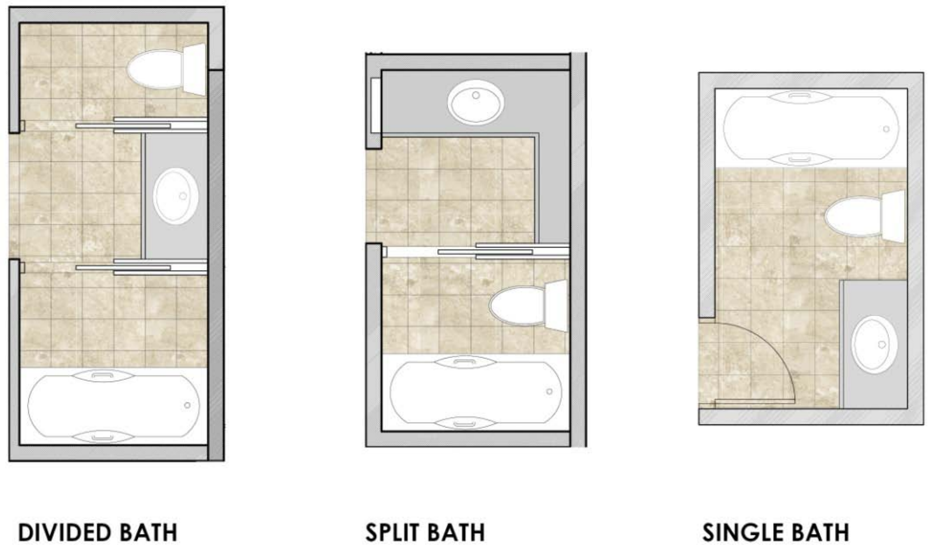


Image 94. Prefabricated Bath Types[291]

[291] Image by Author.

Panelized Elements: Fixed Frame and Flexible Panel

The rest of the dwelling unit will be complete using a standardized partition wall panel system similar to the movable wall systems used in office spaces. This allows for rearrangement of spaces over time. If using a frame and infill panel systems, smaller panel widths make the division of spaces easier.

Overhead Storage

Although the overall dwelling unit design intent is similar to that of a loft apartment, the existing floor to floor height is only 15’-0”. Accounting for the 1’-4” beam depth and 5-inch thick floor slab, the ceiling height becomes 13’-3” high - not quite high enough to allow for a true loft which traditionally includes a partial second story (like a mezzanine). Because of the abundance of height throughout the building, overhead bulk storage can be provided in the ceiling spaces above the bedroom and bath areas. Doing so lowers the ceiling height in private spaces, giving these smaller areas better spatial proportions while providing necessary storage for luggage, paper goods bought in bulk, etc. Access to storage space will be achieved through a retractable ceiling ladder in the wide circulation space near the bathroom.

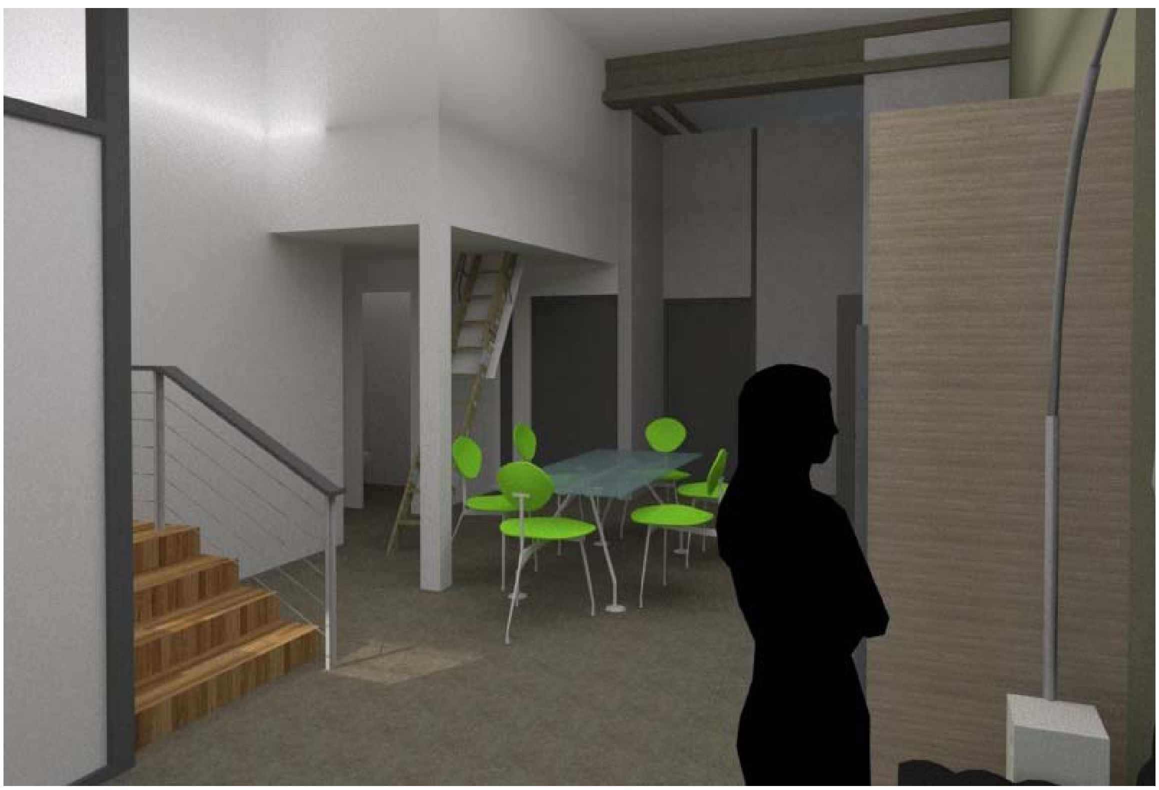


Image 95. Image of Overhead Storage above Prefab Bath[292]

[292] Image by author.

Unit Layouts

The following section provides examples of the typical unit shell plans provided in this project. The images on the right side of the page illustrate possible unit configurations that residents can build out their unit with including the option of buying out an adjacent unit to form one large unit.

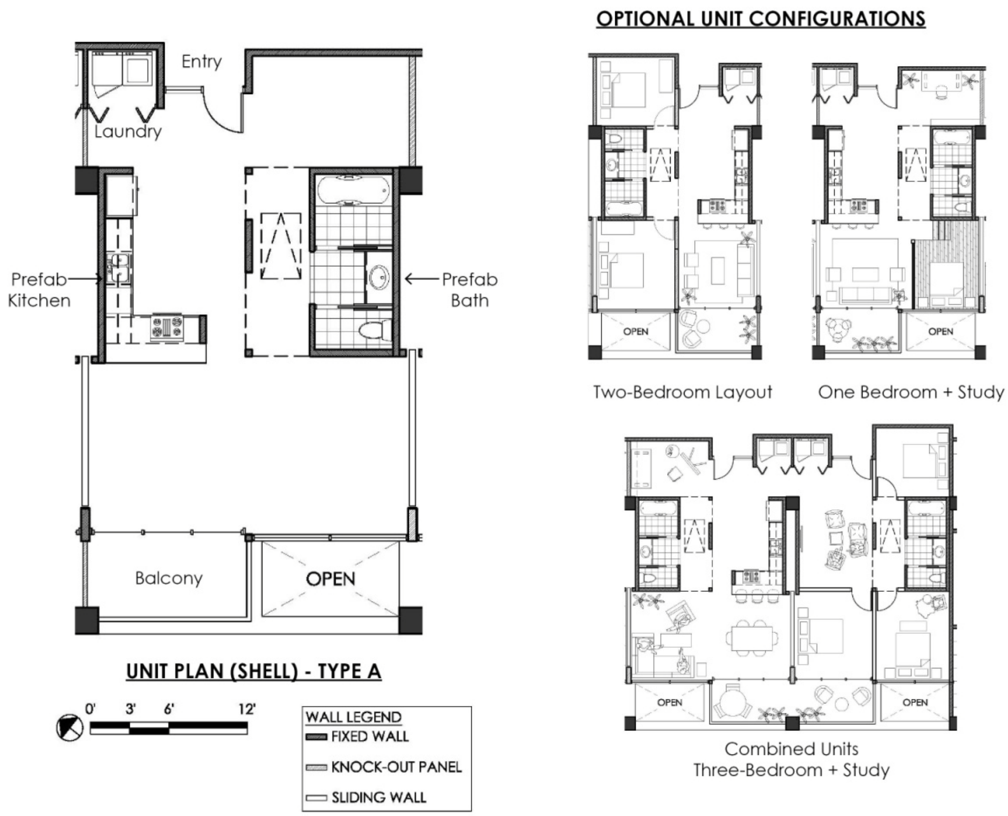


Image 96. Unit Type A - Plan[293]

Unit Type A is the most prevalent unit type in the Light Well and Atrium Schemes. It accommodates either two bedrooms or one bedroom and a study/office/den. Unit Type A is setback 6’-0” from the exterior column line to accommodate a balcony and an open light well. The vanity of the bath unit is separate from the toilet and shower to allow for dual use of the single restroom during peak use (e.g. getting ready in the morning).

In the event that adjacent units are combined, a three or four bedroom unit with two baths can be achieved as shown in the diagrams above.

[293] Image by Author.

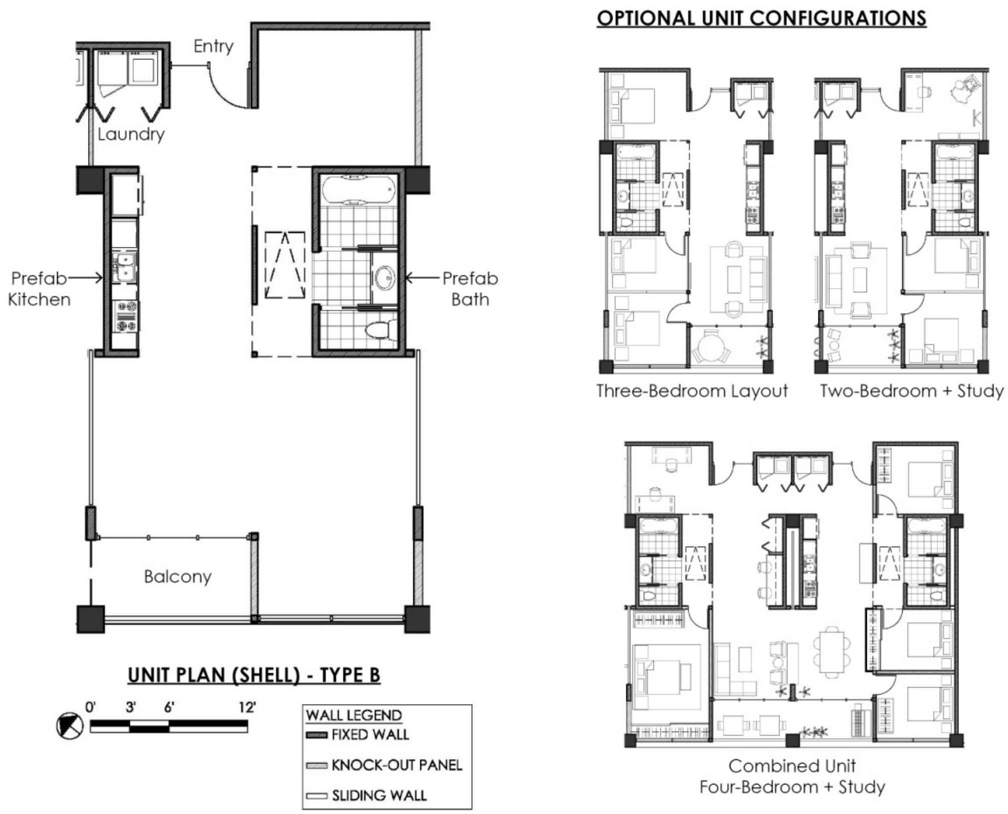


Image 97. Unit Type B[294]

Unit Type B depicts a slightly larger unit than the Unit Type A. The additional space is accounted for the fact that these units extend into the area occupied by the light well shown in the plan for Unit Type A. Unit Type B is used in all three schemes along the Waimanu Street facade. Because the Acquisition Scheme does not require a setback for fire safety along the Kawaiahao Street façade, Unit Type B is also along the Kawaiahao Façade for the this design scheme. Because a three-bedroom, one-bath unit would be disastrous during peak 'getting ready' hours, a divided bath consisting of separate toilet, shower and vanity spaces is proposed to anticipate this situation with minimal space impact.

[294] Image by Author.

Image 98. Unit Type C[295]

Unit C is a hybrid between unit types A and B. There are only two of these units per floor and they are located on the Kawaiahao Street Facade at the ends of the building. Its location between the mechanical vent and the public restrooms determine the size of the unit and allow for a slightly larger balcony area than Unit Types A and B.

Unit C can accommodate two bedrooms or one bedroom plus a study, office, den or workspace near the front entrance. It has one divided bath and an L-shaped kitchen. Unit C can also be combined with an adjacent unit Type B to form a four-bedroom unit.

[295] Image by Author.

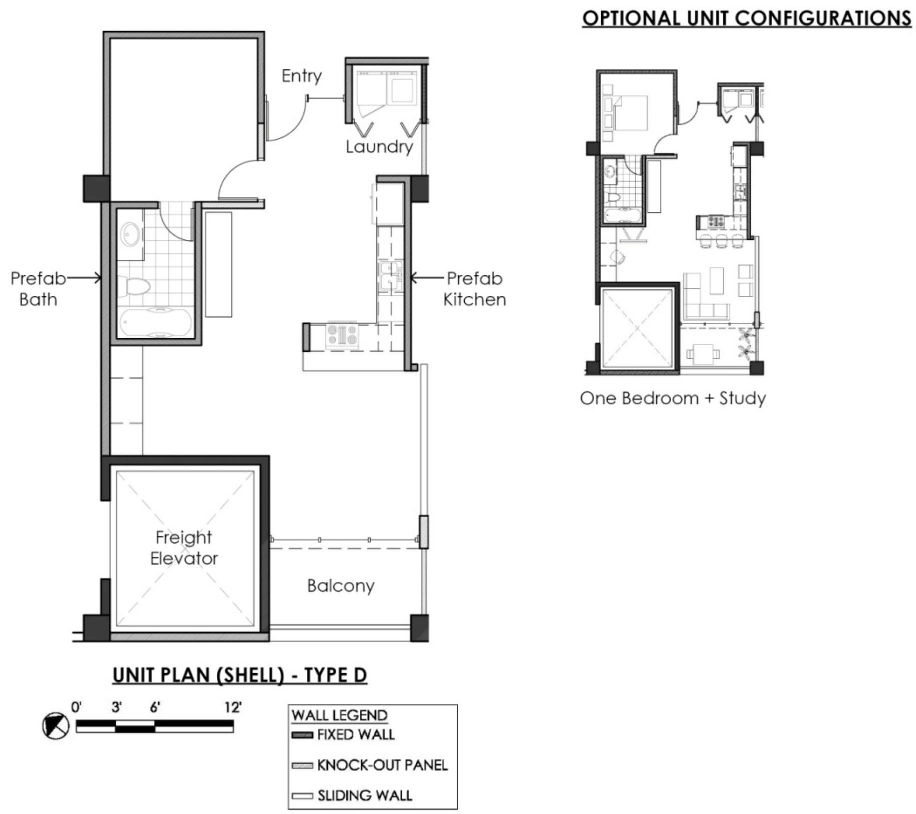


Image 99. Unit Type D[296]

Type D is one of the smaller units that are used in each scheme because of its location next to the freight elevator. It can generally be considered a "one-plus" unit with one bedroom and a nook space that is not quite large enough for a bedroom but can still accommodate a small work space, a small reading area, etc. It also can be joined to the adjacent unit to provide more bedrooms.

[296] Image by Author.

Interior Finishes

Renovations to the building exterior and the creation of cut-outs through the floor slab will generate a considerable amount of demolition waste. Because the construction of the original building is primarily poured-in-place concrete and CMU infill walls, the reuse of demolition debris is limited to crushed applications either as aggregate for new ready-mix concrete applications or pavement, pipe bedding, gravel or pavers for landscaped areas[297] or contained in gabions (caged blocks of crushed rock) for more decorative applications in common area spaces.

Image 100. Example of Image of Gabion[298] & Recycled Concrete Pavers[299]

Without much other reusable material resources to extract from building renovations, the project can also look at utilizing reclaimed materials from surrounding sites in Kakaʻako like salvaged wood from Reuse Hawaii or corrugated metal from neighboring sites.

Applications of salvaged material are primarily to be used in public spaces such as surface decoration for walls in the common areas and amenities spaces such as the backdrop for the performance stage (gabion contained concrete from busting out of atrium spaces), fitness center, clubhouse rooms, or for use at unit entry nooks.

Continuous floor finishes throughout the unit maximizes flexibility throughout the dwelling unit. In the event that room dividers need to be moved around, the flooring for each room is the same and does not need to be replaced. This should apply even under kitchen and bath counters in the event that cabinets beneath sinks need to be removed or altered for ADA accessibility.

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[297] "Markets for Recycled Concrete Aggregate." *Construction Materials Recycling Association.*<www.concreterecycling.org/markets.html> (accessed April 20, 2012).

[298] "Mur en gabin arcagab." *Vert d'Esprit - une marque le l'entreprise Nicolas ERLER.* http://www.vertdesprit.fr/assets/images/specialite/mur_gabion_3.JPG (Accessed April 9, 2012).

[299] Humanbn. "391041642." Flickr.com. http://www.flickr.com/photos/humanbn/3910416482/sizes/o/in/set-72157621917963481/ (accessed April 10, 2012)

Stained and polished concrete floors provide the most economic base flooring material for units. It both appropriate to the industrial aesthetic of the building for this specific project. Other flooring material can be installed on top of concrete floors as well. Restricting the types of flooring installed by the tenant to floating flooring systems (without the use of adhesives), rugs and adhesive-less carpet tiles make it easier retain the quality of the base flooring.

Image 101. Unit Rendering with Linear Kitchen & Garage Doors[300]

The use of a Clopay glass garage door was used to separate the interior living space from the exterior balcony instead of a traditional glass sliding door. Not only does the garage door correspond with the industrial aesthetic of the building and unit design, it also provides a more continuous indoor-outdoor transition when opened.

[300] Image by Author.

4.0 PROJECT COST PARAMETERS

To gain an understanding of whether this new project type would be feasible, the three design schemes described in the previous section were compared based on the programs and square footages that resulted from each design scheme. Linda Schatz, a development manager for Kamehameha Schools' Commercial Real Estate Division, provided information to identify key areas that would affect the financial feasibility of this project. The following section outlines and describes general cost parameters.

4.1 Existing Building Value & Rents

It is important to determine the base value of the existing building in an as-is condition. To determine potentially what the building would sell for, a quick analysis of the building property data on the City and County of Honolulu's Department of Planning and Permitting website provided a reasonable assumption of what the existing property might sell for today. It is important to note however that the above mentioned value per square foot is based on values assigned for tax purposes and does not necessarily accurately represent the actual value of the property.

The table below lists the breakdown between land value and building value as well as provides an overall property value. The property value per square foot is the important number because it is the base to which new construction costs will be added and then later compared amongst similar housing units in the greater Kakaʻako area. This comparison will determine whether this type of housing actually will be more affordable that the housing paradigm in this area currently.

Table 13. Building Value without Improvements (As-Is Condition)[301]

	VALUE	AREA	VALUE PER SF
Land	$8,309,000	54,848 SF	$293
Building	$7,761,000	234,100 SF [302]	$33
Property Value (Land + Existing Building)	$16,070,000	234,100 SF	$69

According to Elizabeth Loomis of Red Tail Acquisitions, LLC who represents the owners of the Kakaʻako Commerce Center, the current asking rent for the Warehouse/Industrial floors are $0.90-$1.00 per rentable square foot per month with maintenance fees being about $0.53 per square foot. The asking rent for office space on the sixth floor is slightly higher at $1.00-$1.10 per rentable square foot with maintenance fees at $0.67 per square foot per month. The

[301] Property Information, "875 Waimanu Street," City and County of Honolulu Department of Planning and Permitting. (Accessed 20 January 2012)

[302] City and County of Honolulu Department of Planning and Permitting. http://dppweb.honolulu.gov/DPPWeb/default.asp?PossePresentation=TaxMapKey&PosseObjectId=35204 (Accessed 30 January 2012).

building also generates income from parking fees of $90 per month for a single stall and $160 per month for a tandem stall.[303]

Table 14. Summary of Kaka'ako Commerce Center Current Rent Prices [304]

RENTAL RATES	RENT PER RSF/MONTH	ESTIMATED 2012 CAM PER RSF/MONTH
Warehouse/Industrial Floors 1-5	$0.90 - $1.00	$0.53
Office Space Floor 6	$1.00 - $1.10	$0.67
Parking Rates	**Cost/Month**	
Single Stall	$90.00	
Tandem Stall	$160.00	

The following table calculates the value per square foot of the project based on the amount of rentable floor area in an unimproved state. The rentable floor area was calculated based on the Light Well Scheme which was considered the base model for comparison purposes. The value per square foot was calculated by dividing the property value by the rentable floor area. This value represents existing value of the building per square foot without improvements.

Table 15. Cost per Rentable Square Foot Before Improvements

USE	RENTABLE FLOOR AREA (BASED ON LIGHT WELL PROGRAM)	VALUE PER SF*
Commercial (Floor 1)	22,749 SF	
Residential (Floors 2 –6)	86,135 SF	
Property Value	$16,070,000	
Total Rentable Area (Floors 1-6)	108,884 SF	$147.59

* Based on Property Value outlined in Table 8.

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[303] Elizabeth P. Loomis, *Red Tail Acquisitions, LLC.* email to author, February 28, 2012.

[304] Ibid.

4.2 Comparative Housing Asking Prices in Area

While this project does not attempt to determine actual project costs for the designs proposed above, it is helpful to understand what comparable units in the Kaka‘ako area are selling for. This information will be particularly helpful when project developers conduct residual value studies and project pro formas.

The following table compares the average asking price per square foot for available condominiums of three recently built condominiums - the Vanguard Lofts, Imperial Plaza, and 909 Kapiolani. All three buildings are located within one block of the project site. Appendix B provides a more specific break-down by individual unit, listing the unit type (1 bedroom, etc.), unit size, asking price, and price per square foot.

Table 16. Average Condominium Prices in Greater Kakaako Area

	BUILDING	PRIMARY UNIT TYPES	AVERAGE UNIT SIZE	AVERAGE ASKING PRICE	AVERAGE PRICE PER SF
	**The Vanguard Lofts**[305] 720 Kapiolani Blvd.	2-3 bedroom	1,394 SF	$ 965,000	$ 614.97
	**Imperial Plaza**[306] 725 Kapiolani Blvd.	2-3 bedroom	1,746 SF	$ 926,127	$ 511.68
	**909 Kapiolani**[307] 909 Kapiolani Blvd.	1-2 bedroom	710 SF	$ 498,571	$ 665.07
	**Pacifica Honolulu**[308] 1250 Kapiolani Boulevard	1-2 bedroom	865 SF	$469,492	$700.92*

* Indicates Market Rate Condos only. Pacifica Honolulu's Reserved Housing Unit Asking Price average is about $484.91 per square foot (see Appendix C for price by unit for Reserved Housing Units). If combined, the average asking price for a condominium at the Pacifica Honolulu is $592.92 per square foot.

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[305] Clayton Cooke, LLC. *The Vanguard Lofts.* http://www.thevanguardlofts.com/lofts/units.php (Accessed 26 January 2012).

[306] Condo.com. *Imperial Plaza.* http://honolulu.condo.com/Condo_Honolulu_96813_Imperial-Plaza_3850827/ForSale (Accessed 26 January 2012).

[307] Honolulu Condos. *909 Kapiolani*. http://www.hicondos.com/hawaii-Condos/909-Kapiolani.asp (Accessed 26 January 2012).

[308] Pacifica Honolulu. "Sales: Price/Availability." http://www.pacificahonolulu.com/floor-plans# (Accessed January 30, 2012).

4.3 Adjacent Property Acquisition Costs

With the existing structure built right up to the property line, it becomes problematic to locate residences along the Kawaiahao Street facing façade. In the event that the immediate adjacent properties are acquired and developed by another developer, new buildings can potentially be constructed up to 65'-0" high according to the Kakaako Mauka Area Plan.[309] This would mean that residents on the second and third floor of this property would only have views of the backside of a building, creating a highly undesirable living condition.

An option to consider, in this scenario, would be for the developer of this project to buy out the six adjacent lots from the current four owners. Doing so would allow the developer to prevent these lots from encroaching on the view of residents along the Kawaiahao Street facing façade, and could potentially provide more opportunities for additional parking, open green space, and/or commercial retail space at the ground level and second floor.

This solution however involves a lot more money at the expense of the potential resident. The total value of these adjacent properties is roughly $4.8 million for an additional 25,000 SF (see Table 17 for summary breakdown). An evaluation must be made to determine whether the added value to the property (aesthetically, physically, and design features) exceeds the expense of acquisition and development of said properties.

Table 17. Adjacent Property Values & Data[310]

TMK	OWNER	LAND VALUE	BUILDING VALUE	AREA (SF)
21049049	John and Yue Kwan	$581,400	$41,600	3,600
21049048	John and Yue Kwan	$535,900	$0	3,318
21049047	John and Yue Kwan	$504,500	$0	3,124
21049046	The Assieh LLC	$807,500	$24,500	5,000
21049043	TM Family Ltd. Part.	$807,500	$325,600	5,000
21049042	AH&K Corp	$807,500	$315,800	5,000
TOTAL ACQUISITION VALUE:			**$4,751,800**	**25,042**

309 "Figure NZ.5 – Central Kakaako (CK) Zone." September 2011. < http://hcdaweb.org/kakaako/plans-rules/mauka-area-plan-and-rules/Neighborhood%20Zone%20NZ.1-7.pdf/download> (Accessed January 23, 2012).

310 "Property Information." City and County of Honolulu Department of Planning and Permitting. <http://gis.hicentral.com> (accessed March 22, 2012).

4.4 Savings on Construction Costs

In 1971 when the building was constructed, the estimated cost of construction was $2,250,000.[311] In today's market, the cost to build a similar structure with a comparable structural load capacity would be considerably more expensive. By reusing the existing structure, the project is able to save a significant amount of money on hard costs alone.

Reduction of Prefabricated versus On-site Construction

The use of prefabricated components in the dwelling units can be assumed to reduce construction costs. In an internet search, the generally accepted cost savings of a prefabricated home is generally 20% less expensive than a site-built home.[312] For the purposes of this project this percentage can be factored into the construction costs to anticipate the cost savings of prefabrication (or preassembled) construction over on-site construction.

Parking Costs

Providing parking is often very expensive to construct. Schatz used an estimated cost $6,740-$9,000 per stall for surface parking and $24,000-30,000 for structured parking. [313]

One of the significant benefits of the building selected for this project was the abundance and flexibility of existing vehicular parking and the ability for the existing structure to accommodate more parking throughout the building. For this reason, we can safely assume any additional parking stalls that are required by the change in building use can be provided for no more than the cost of surface parking.

There are currently 93 stalls on the roof deck, 27 of which are tandem stalls and able to accommodate two vehicles, which provides a fair amount of the required resident parking in most schemes. A few new parking stalls will actually replace some existing parking on each floor level but the goal is to provide as many stalls as is taken away. The cost for this portion should be rather minimal. In total, an average of at eight parking stalls shall be provided per floor (with exception of the 6th floor which has no vehicular access). Furthermore, for all design schemes, additional 15 surface parking stalls will be located along the Waimanu Street facade. For the lot acquisition scheme, an additional 34 surface parking stalls will be also be located on the acquired properties to accommodate the demands of additional commercial ground floor use.

New Passenger Elevator

Currently there is one passenger elevator and one freight elevator, located at two different locations in the building. Because the freight elevator only allows access to the fifth floor, the inclusion of a second passenger elevator would be necessary in the event that the original

[311] City and County of Honolulu Department of Planning and Permitting Data and Image Resourcing Department. "855 Waimanu Street." Building Permit #71160. October 11, 1968.

[312] Xaxx, Jagg. "Cost of Pre-fab or Mobile Built Home vs. Eco Home." http://www.ehow.com/info_8032510_cost-home-vs-eco-home.html (Accessed April 9, 2012).

[313] Linda Schatz, interview by author, April 9, 2012.

passenger elevator breaks down. Luckily, a review of the existing building plans revealed that the storage space directly adjacent to the existing passenger elevator has a removable lid on each floor, allowing for the possibility of adding a second elevator.

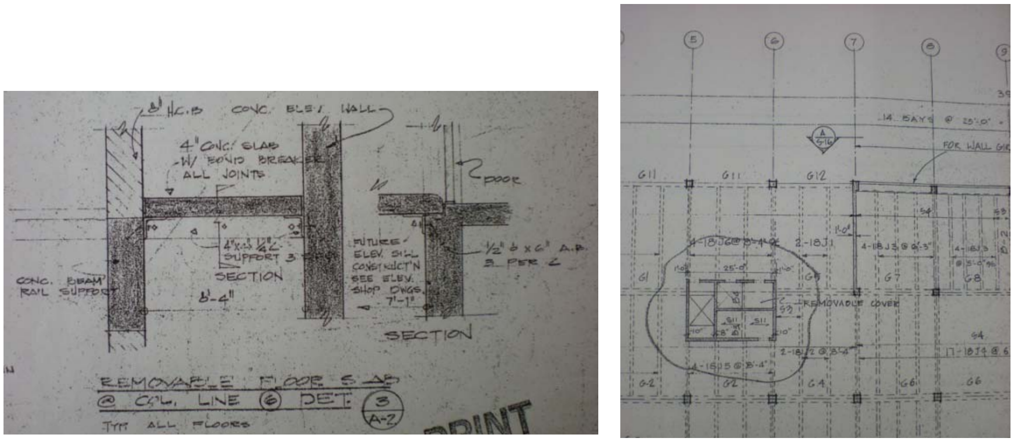

Image 102. Architectural & Structural Drawing of Removable Floor Slab for Second Elevator[314]

[314] Hsi, Hwei-Yang. "Waimanu St. Development for the Hawaii Corp," Structural Engineering Drawings for Building Permit Application. October 14, 1969, A-2, S-3.

4.5 Efficiency Ratios

An efficiency ratio is a ratio of the amount of billable floor area to the amount of usable floor area. Because the cost of the entire building is incorporated in the price of a unit, greater efficiency ratios generally mean that the cost is spread out over either more units or more square footage, increasing the value of the project.

Based on the initial programming, which, was based on the location of existing circulation cores and determined by the existing structural bay, the following efficiency ratios were calculated for the residential floor areas for the three design schemes:

Table 18. Efficiency Summary of Design Schemes

DESIGN SCHEME	GROSS (BILLABLE) AREA	NET (USABLE) AREA	EFFICIENCY
Acquisition Scheme	78,831 SF	152,849 SF	52%
Light Well Scheme	73,015 SF	151,074 SF	48%
Atrium Scheme	62,443 SF	150,204 SF	41%

The efficiency ratios for all design schemes of this project are very low. Typically an efficiency ratio of 80% is preferred. A few hypothetical scenarios were tested to increase the efficiency ratio including converting the second amenities space near the passenger elevator lobby into a dwelling unit, extending units into the excess corridor space at the ends of the corridor nearest the existing public restrooms and stairwells, and by extending all units into the corridor to improve floor area efficiency.

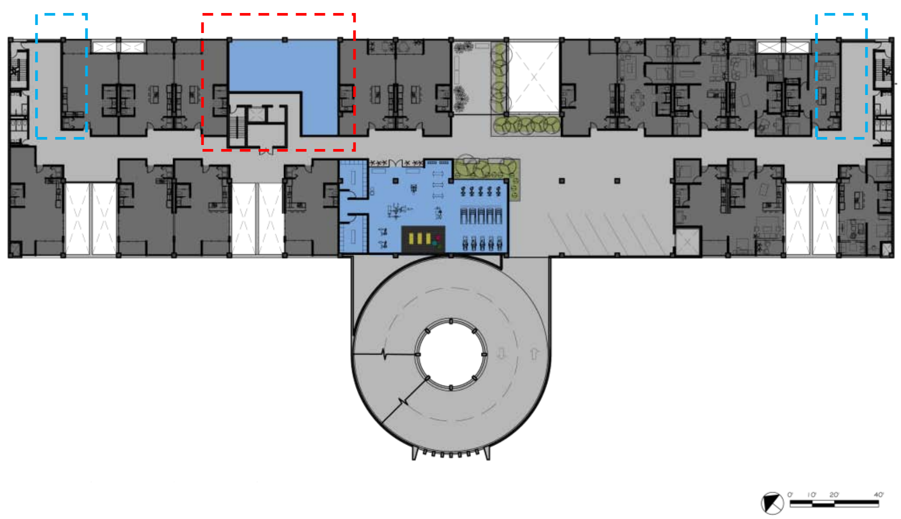

Image 103. Potential Areas to Improve Efficiency (Atrium Scheme Shown)[315]

[315] Image by Author.

Despite the above mentioned improvements, the constraints of the existing structure limit the efficiency of the units. The best efficiency ratio that was achieved involving all of the abovementioned suggestions was only 52% on the lot acquisition scheme. Part of the inefficiency is because each floor accommodates 5 parking stalls and a very large amenities space which is dictated by the location of the circular vehicular ramp. These spaces cannot be changed because of the required parking demands. Therefore, it is unlikely that a better efficiency ratio can be achieved becoming problematic in terms of affecting the value and profitability of this project.

4.6 Utility Upgrades & Infrastructure Improvements

As mentioned in the Site Context section of this document, the Central Kakaʻako neighborhood in which the project is located currently does not have the infrastructural capabilities to support the change of an industrial warehouse building into a residential mixed use project, despite the goals and proposals of the HCDA's Mauka Area Plan.

Because HCDA has no immediate plans to upgrade or upsize water and sewer lines on Waimanu Street or Kawaiahao Street, depending on the timing of the project, the responsibility of these improvements is likely to fall upon the developer. HCDA may also require some amount of roadway improvements – particularly along Kawaiahao Street – to provide sidewalks for pedestrians coming and going to the project site. This may become a significant cost factor for the project.

4.7 Summary

The biggest variable that could make or break the project is the level of roadway, sewer, water, and other infrastructural improvements that HCDA will impose on the project for its change in use from a warehouse industrial building to a residential mixed use. The rest of the cost parameters are relatively manageable in comparison. Should HCDA improve infrastructure to attract development, this variable could become less significant.

However, due to the programmatic limitations set by the existing structure, the project as a standalone development is unlikely to be profitable if following conventional housing development delivery methods. The project density and efficiency ratios are too low to offset retrofitting costs for improving infrastructure and bringing up the building to meet housing and building codes, especially if the units are sold at reserved housing prices.

For these reasons, it is unlikely that the design project can be considered financially feasible and profitable. During a few of this doctorate project's committee meetings, committee member Sanford Murata suggested that this project could be developed completely as reserved housing units and be sold to another Kakaʻako developer to meet its reserved housing requirements off - site or sell off its reserved housing credits in order to help fund the project.

As part of its Mauka Area Plan, Kakaʻako's Reserved Housing Program requires that for lots of 20,000 SF or more twenty percent of the project's residential floor area should be housing reserved for those who earn 140% or less of Honolulu's area median income. Although HCDA prefers developers to provide reserved housing units on the same site the reserved housing program allows for off-site reserved housing and in-lieu fees – a provision that is highly beneficial to this project.

This proposal may be particularly appealing for developers of luxury apartments in the Kaka'ako district because they can generally get higher profits from their luxury residential development that can help offset the purchase of the reserved housing development & construction costs proposed by this project. Depending on the design scheme selected, this adaptive reuse project can provide 91 reserved housing units (104,069 SF). With HCDA's 20% reserved housing rule, this project can meet the reserved housing requirement for projects up to 455 units (or 520,345 SF).

5.0 CONCLUSIONS & IMPROVEMENTS

During committee discussions of this project, the concern of the design portion of the project being geared toward the adaptive re-use of a 'white elephant' building was brought up – meaning that this method of housing design would only be applicable to this building; the final product is something that cannot be applied to many other building types in Honolulu. To an extent, this is true – there are not a lot of buildings like the proposed building in Hawaii. But perhaps the greater purpose of this project is found in the design process – considering the lifecycle of the building, the understanding of relationships between building systems and relationships between various types of experimentations in housing – in order to gain housing solutions that are cost-effective and still charismatic.

From this perspective, finding a prototype form for urban housing doesn't work – Honolulu ends up right back to where we are right now but with perhaps a different form of housing. The notion of a 'prototype' implies a one-size-fits-all solution. One of the reoccurring themes throughout this paper is the emphasis on user control and identification within one's neighborhood, building and dwelling as a key role in the success of urban multifamily housing. In this sense, everything has to fit. Given that Honolulu is a hodgepodge of smaller but distinctive neighborhoods, one architectural solution cannot be applied appropriately to the characteristics and demographics of all the neighborhoods.

As Stephen Kieran and James Timberlake express in response to similar critique of the Loblolly House by Michael Stacy:

> *While it is true that the landscape of modernism has seen countless prefabricated one-offs, the problem lies not with the architects' good intentions – to implement an affordable prefab house for the masses – but with the concept of 'prototype,' as it is applied. As we see it, there is too much 'type' and not enough 'proto.' Type suggests something ultimately recognizable, having attained a status of its own. Proto implies origins and the process of arriving at a potential solution. While we are all for 'proto,' we have reservations about 'type' and feel there is no such final solution; there are only evolving sets of elements that help us make better decisions.*[316]

In a similar sense, this dissertation argues the same point: that the 'prototype' for this solution of Honolulu's urban housing affordability is maybe found in concept and in design process rather than in the physical manifestation of the product itself.

The design of this project proposes a method of standardization that goes beyond the fixed cookie-cutter approach of affordable housing production in Hawaii. It looks at traditional methods of urban housing production and design to strategize an approach that creatively and appropriately addresses issues surrounding urban housing affordability in Hawaii.

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[316] Stephen Kieran and James Timberlake. *Loblolly House: Elements of a New Architecture.* (New York: Princeton Architectural Press, 2008), 142.

Urban housing in Hawaii can benefit from employing more sustainable design practices despite initial upfront costs. Passive cooling, alternative energy production, water reclamation and conservation can all aide in reducing long-term operating costs for the building. A similar sentiment is expressed by William R. Morrish, Susanne Schindler, and Katie Swenson in their book, *Growing Urban Habitats,* which documents an international design competition for the redevelopment of a trailer park in Charlottesville, VA: "Sustainable building requires the same logic as planting urban trees: upfront investment in design time and development costs for long-term pay back. Doing so results in two 'green' benefits, one ecological, the other economic. These two greens are inextricably linked. Environmental smartness is invariably financial smartness."[317]

The reuse of existing building stock is perhaps one of the most sustainable development approaches.[318] This project's initial goal of designing housing to support a recycling and reuse industry to affect construction costs has some merit, but the current trajectory of housing construction, Hawaii waste management practices, global material production, and general preconceived notions against salvaged materials (at least structurally) makes this goal a short-sighted solution that will take a long time in developing effectiveness. Instead, the reuse of an entire building is a much more viable option that has more significant and more immediate effects on housing construction costs.

For the most part, urban infill and adaptive reuse goes against Hawaii's conventional method of providing housing that is affordable due to the high cost of land in urban environments as well as the desire to cater to market demands for the American dream of home ownership of the single family house. The benefit of housing in urban environments however is that projects is that in usual cases, roadways and other infrastructure are already in place. If the structure is sound and can accommodate a variety of uses with minimal structural repairs or alterations, the project is in even better shape. However, as illustrated by the proposed design project, site selection is a vital decision that affects the success of an adaptive reuse project. Selecting a neighborhood that has existing infrastructure that can adequately accommodate higher demands of residential use is ultimately ideal.

There are numerous ways to achieve cost savings in housing construction however, often times, the design decisions are based on immediate needs and demands on a particular time and place. Even adaptive reuse projects should design with considerations of lifecycle building, prefabrication and housing flexibility in mind. In doing so, urban housing (as well as buildings in general) in Honolulu can increase and extend their useful lives. The design of new buildings with these principles in mind will also increase the amount of building stock that is suitable for adaptive reuse projects as well.

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[317] William R. Morrish, Susanne Schindler, and Katie Swenson. *Growing Urban Habitats: Seeking a new housing development model.* (Richmond: William Stout Publications, 2009), 178.

[318] William R. Morrish, Susanne Schindler, and Katie Swenson. *Growing Urban Habitats: Seeking a new housing development model.* (Richmond: William Stout Publications, 2009), 222.

Given the cost parameters outlined in Section 4.0, there are a considerable amount of variables that affect the financial feasibility of this project negatively based on conventional urban housing delivery models and methods. As mentioned in Section 4, as a stand-alone development, this project would not be profitable. However, by proposing the project as a reserved housing development that could be sold (either to another Kakaʻako developer or in the form of affordable housing credits), the project takes advantage of its affordability to help offset its costs. Still, the design process and considerations discussed throughout this paper still hold merit for affecting the future of housing affordability in Hawaii, even if its effects might not be seen for some time.

Urban multifamily housing design requires a balance between standardization with resident identification. While some believe resident identification may be achieved through variation (for example providing different unit layouts or different finish material options), resident identification can also be provided through participation, whether through the design of the space or the physical construction or adaptability of it. In fact, user identification through participation provides a stronger and more durable relationship between users, their dwellings and their neighborhood. This, in turn, encourages neighborhood camaraderie and security.

The fact is however, that nothing about architecture is in fact permanent. Needs change, desires change, styles change, materials change, costs change. The solution for housing affordability proposed by this project is to anticipate and take advantage of these changes. The difficulty is proving that doing so will add value to a project through quantifiable methods.

However, the project design's appeal is heavily grounded in response to its chosen site, the existing physical conditions of both neighborhood and building structure, and Kakaʻako's economic, political and social conditions. While the over-arching principles of lifecycle building, prefabricated elements and methods of flexibility can technically be applied to any building, it's the proposed uses and functions of the building's program and anticipated clientele that make the project special and unique.

A possible expansion or extension of this paper may be to propose that elements of the design approach for adaptive reuse can be carried forth as a way for future housing in Hawaii to be built so that it continues to change and adapt to the needs of its users. Using notions of building systems layering, material lifetime considerations, and separating structure from building use can all easily be applied to new buildings to upgrade their potential for reuse down the road. Flexible design elements in a new construction scenario would be easier to standardize and allow more opportunities for pre-and post-occupancy adaptability, but the likelihood of such a project being considered 'affordable' in any sense could be lost given the high costs associated with new construction of site development and the building structure.

Future research could also extend to consider which buildings in Honolulu have the highest reuse potential based on the principles outlined for the building selected for the design portion of this project. In this scenario, the feasibility of the proposed design process as a wide-spread solution for housing affordability can be more fully realized.

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APPENDIX A: BUILDING MATERIAL REUSE

The following performance criteria was used to evaluate the reuse potential in commonly used building materials in Hawaii during a research project conducted by the author during the Spring 2011 semester.

Performance Criteria

Aging

- Does the material have a patina as it ages?
- How does the material's appearance change over time? Is it a good change?
- How does the material's physical strength change over time? Does it become brittle or weak?

Product Life & Durability

- How permanent is the material?
- Is it water resistant?
- Is it susceptible to insect damage?
- Is it susceptible to rust or corrosion?
- How strong is the product structurally? Is it susceptible to abrasion?
- How long is the product expected to last?
- Is it combustible?

Availability

- Are raw materials available locally?
- Are there local manufacturers?
- How common is this building material in Hawaii homes?
- Is there an abundance of this material used in existing homes?
- How much of this material on average can be salvaged from one building?

Installation Methods

- What type of fastener is required? Permanent or non-permanent?
- Does this product require adhesives?
- Does this product require sealants or treatments? Are they easily removable?

Environmental Impact

- Does this material contain any toxic chemicals?
- Does this product impact air quality? Fumes, airborne particles?
- Is production of this material energy-intensive?
- Is recycling this material energy intensive?
- Does this material have a high embodied energy?

- Does this material afford any LEED Credits?

Human Health Concerns

- Can this material cause respiratory problems? (Mold/Mildew, VOCs)
- Does this material contain any particles that can cause skin or eye irritation?
- Is this product toxic?

Labor

- How difficult is this product to disassemble?
- Does its removal require a specific type of expertise and/or equipment?
- Does this material require refinishing? Does refinishing require any type of special expertise/equipment?

Alternative Applications/Flexible Use

- Can this material be used in a variety of applications? (e.g. flooring to soffit finishes to decking, etc.) Does it need re-milling/reworking to do so?
- Can this material be used in both exterior and interior applications?

Research Summary & Conclusions

In order for a successful reuse industry in Hawaii to take off, several issues need to first be addressed from the supply side. The most pressing concern seems to be the toxicity of various chemicals present in all types of building materials significantly hinders end-of-usable-life potential.

Most designing for deconstruction guidebooks value high quality organic and renewable materials over the inflexibility of synthetic materials that is inherently permanent. Wood is commonly named as the structural material that has the highest reuse potential although for Hawaii, supply is somewhat limited to smaller members because of the type of residential construction that has been historically built in the islands. Unfortunately, natural/organic materials are subject to more biological contaminants than synthetic materials are and chemical treatments used to combat these contaminants render these potentially valuable materials unfit for future reuse.

Synthetic materials made out of plastics while supposedly “renewable” and constantly recyclable, are particularly problematic for reuse because they are unable to be refinished when damaged and there are numerous environmental and human health concerns associated with the materials. Composite products such as engineered wood face similar issues because of the formaldehyde and other chemicals present in the resins and adhesives used. While many of these synthetic products claim to be maintenance free and moisture and insect resistant, its physical durability to wear and elemental exposure make its usable life below most other organic or natural alternatives (for example, synthetic fiber carpet versus wool carpets).

Additionally, the various adverse health and environmental effects which are associated during manufacturing and immediately following installation of many plastic and composite products are raise concern for the safety of homeowners in the long-run.

With limited raw material resources and rising concerns about costs by consumers both locally and abroad, the use of synthetic and/or composite materials are inevitable. Unfortunately, as McDonough and Braungart point out, effective recycling of building materials suggest that organic and inorganic materials be kept separate or at least not permanently connected to minimize cross-contamination.[319] The same can be said for reuse.

Particular for Hawaii, the natural elements play a major factor in the amount of reusable building material from homes. High humidity, corrosive salt air, and termites wreak havoc on most building materials. Choosing materials that are appropriate and durable for Hawaii's climate will not only preserve the life of a home, but it will increase the chance of that product having a second life through reuse. Passive building design strategies such as non-chemical termite prevention and proper ventilation of walls and spaces are also viable and environmentally responsible solutions that can help elongate the life and integrity of potential reusable building materials.

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[319] William McDonough and Michael Braungart. *Cradle to Cradle.* (New York: North Point Press, 2002), 92-93.

APPENDIX B: COMPARATIVE HOUSING PRICES IN KAKA‘AKO

Table 19. Kaka'ako Area Comparative Housing Price Data

BUILDING	UNIT NO.	UNIT TYPE	UNIT AREA (INTERIOR)	UNIT AREA (EXTERIOR)	ASKING PRICE	PRICE PER SF
The Vanguard Lofts[320] 720 Kapiolani Blvd.	306	2 bed, 2 bath	1,333	102	$895,000	$623.69
	308	3 bed, 2 bath	1,407	188	$935,000	$586.21
	504	3 bed, 2 bath	1,455	206	$1,025,000	$617.10
	507	3 bed, 2 bath	1,382	206	$1,005,000	$632.87
				Average	**$ 965,000**	**$ 614.97**
Imperial Plaza[321] **725 Kapiolani Blvd.**	614	2 bed, 2.5 bath	1,291		$625,000	$484.12
	3003	2 bed, 2.5 bath	1,308		$628,888	$480.80
	1604	2 bed, 2 bath	947		$503,000	$531.15
	3707	2 bed, 2.5 bath	2,008		$999,999	$498.01
	PH3503	3 bed, 3 bath	2,133		$848,000	$397.56
	PH3903	3 bed,	3,293		$2,250,000	$683.27

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320 Clayton Cooke, LLC. *The Vanguard Lofts.* http://www.thevanguardlofts.com/lofts/units.php (Accessed January 26, 2012).

321 Condo.com. *Imperial Plaza.* http://honolulu.condo.com/Condo_Honolulu_96813_Imperial-Plaza_3850827/ForSale (Accessed January 26, 2012).

		3.5 bath				
	601	3 bed, 2 bath	1,239		$628,000	$506.86
				Average	$ 926,127	$ 511.68
909 Kapiolani[322] 909 Kapiolani Blvd.	1208	1 bed, 1 bath	607	42	$429,000	$661.02
	1806	1 bed, 1 bath	601	42	$438,000	$681.18
	3105	1 bed, 1 bath	618	42	$440,000	$666.67
	2608	1 bed, 1 bath	607	42	$455,000	$701.08
	2203	2 bed, 2 bath	850	42	$555,000	$622.20
	2503	2 bed, 2 bath	850	42	$578,000	$647.98
	1502	2 bed, 2 bath	839	42	$595,000	$675.37
				Average	$ 498,571	$ 665.07
The Pacifica Honolulu[323] 1250 Kapiolani Blvd.	4106	1 bed, 1 bath	661		$468,290	$708.46
	4006	1 bed, 1 bath	661		$466,960	$706.44
	3906	1 bed,	661		$465,630	$704.43

[322] Honolulu Condos. *909 Kapiolani.* http://www.hicondos.com/hawaii-Condos/909-Kapiolani.asp (Accessed January 26, 2012).

[323] Pacifica Honolulu. "Sales: Price/Availability." http://www.pacificahonolulu.com/floor-plans# (Accessed January 30, 2012).

	1 bath				
3806	1 bed, 1 bath	661		$464,300	$702.42
3606	1 bed, 1 bath	661		$461,640	$698.40
3506	1 bed, 1 bath	661		$460,310	$696.38
3406	1 bed, 1 bath	661		$458,980	$694.37
2709	1 bed, 1 bath	732		$509,828	$696.49
			Average	**$469,492**	**$700.92**

APPENDIX C: PACIFICA HONOLULU RESERVED HOUSING UNITS

The following table is a list of the range of sale prices for reserved housing units at the Pacifica Honolulu, located in Kakaʻako.

Table 20. Pacifica Honolulu Reserved Housing Units[324]

FLOOR	UNIT TYPE	UNIT AREA	PRICE RANGE		PRICE/SF	# OF UNITS
6-12, 15-24	B/BR 2 bed, 2 bath	747	$360,000	$420,000	$522.09	34
6-12, 15-24	A/AR 2 bed, 2 bath	728	$350,000	$408,400	$520.88	34
6-12	C/CR 2 bed, 2 bath	798	$395,000	$424,000	$513.16	14
6-12	D/DR 2 bed, 2 bath + den	986	$425,000	$454,700	$446.10	14
6-12	E/ER 2 bed, 2 bath + den	899	$410,000	$437,000	$471.08	14
6-12	F/FR 2 bed, 2 bath + den	1033	$435,000	$466,050	$436.13	14
				Average:	**$484.91**	

[324] Pacifica Honolulu. "Owner-Occupant (Reserved Housing) Presale Announcement." http://www.pacificahonolulu.com/floor-plans# (accessed January 30, 2012).